Health Impact Assessment of Mountaintop Mining

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Appendix A. Assessing Health Impacts of Mountaintop Mining: Protecting Public Health in Appalachia
ABSTRACT

Health Impact Assessment of Mountaintop Mining
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Background: Mountaintop mining (MTM) is one of the most high profile environmental issues in the United States. The adverse environmental impacts of MTM have been determined after extensive litigation between citizen groups, government agencies, and industry as well as heavy opposition from environmental activists. However, there is little evidence on the human health effects caused by MTM. Environmental Justice (EJ) is also a pertinent issue when evaluating the impact of MTM on public health. A Health Impact Assessment was created to provide a tool for public health officials, policy makers, industries and community members to better understand the health impacts of MTM and aid in the development of policies that mitigate the health risks of this practice.

Methods: An extensive literature review was conducted to establish the current status of MTM studies regarding impacts on human health. Inquiries were made to several academic institutions with known interest in studying the human health impacts of MTM including Duke University and West Virginia University. The specific EJ components of MTM were determined through meetings with EPA and CDC stakeholders, a literary analysis, as well as with a personal visit to West Virginia mining communities. Future study designs and interventions were based on an evaluation and critique of current literature by CDC officials and through the examination of current and prospective EPA Cumulative Impact Assessment projects.

Results: Compiled literature shows weak evidence for various human health impacts of coal mining exposure including heart and kidney disease and certain cancers. However, there are no completed or active human health studies of MTM impacts available. EJ component of MTM has been confirmed based on Census data showing high poverty rates throughout most of Appalachia. There are several federal and academic efforts underway to evaluate the human health and EJ impacts of MTM.

Conclusions: Based on scientific evidence regarding coal mining and human health impacts, an extensive EJ evaluation, and a thorough environmental impact assessment, epidemiologic studies are necessary to mitigate the human health risks of MTM. Collaborative efforts by the CDC, ATSDR, EPA, and academic institutions are necessary to connect environmental impacts with the health risks posed by MTM.
Introduction

Currently, Mountaintop Mining (MTM) is one of the most high profile environmental issues in the United States Environmental Protection Agency (EPA). Much focus has been invested in assessing the ecological impacts of the MTM industry. However, there is growing interest and need within the EPA to understand the community health risks associated with MTM. West Virginia University and Wheeling Jesuit University have conducted preliminary research on health impacts of MTM, and Duke University has recently initiated a more comprehensive study to look at ecological as well as human health impacts. Initial results of these studies suggest toxic dust in the air and well water contaminated with chemicals from mines could potentially have adverse human health impacts (Palmer et al., 2010). Some of these health effects include elevated rates of lung cancer, heart disease and increased adult hospitalizations for chronic pulmonary disorders and hypertension as a function of county-level coal production (Palmer, et al., 2010). Thus far, research is suggestive of excess health risks associated with MTM exposure. However, validity and comprehensiveness of these findings remain in question. Given the national level attention and priority of MTM impacts within EPA and other federal agencies, this is an area where more rigorous assessment of the overall health impacts is greatly needed.

There are several tools of evaluation and assessment, which provide insight about the magnitude and health impacts of an industrial practice such as MTM. Some of these tools include epidemiological studies, governmental exposure investigations, targeted environmental sampling, and health impact assessments (HIA). HIA is a beneficial tool for public health, community members, and policymakers because it helps ensure that health remains a critical consideration when developing policies. An effective HIA will utilize components from the other
evaluation strategies in order to form a thorough appraisal of MTM and its potential adverse human health impacts. The goal of this project will be to generate a comprehensive HIA for MTM in West Virginia.

Creating a HIA for MTM is significant because so far, only environmental impacts of this practice have been investigated. A multitude of harmful environmental effects from MTM have been determined through the joint efforts of many governmental organizations. However, the human health risks of MTM have not been adequately studied potentially leaving the populations living near mining sites in jeopardy. An HIA will increase understanding of health risks that MTM poses to the surrounding communities and will propose possible public health interventions to mitigate those risks. It will also evaluate current research about MTM health impacts and the effectiveness of current government regulations of the industry. MTM also possess an environmental justice component because the communities in the affected areas are vulnerable to public health threats and politically disparaged. Thus, this HIA will address the multifaceted nature of mountain top mining and many of its potential public health consequences.

**Background and Significance**

**Mountain Top Mining**

Mountaintop Mining (MTM) is type of a surface mining that has been practiced in some form since the 1960s. MTM involves the removal of mountaintops to expose coal seams. Explosives and earth moving machines called draglines are used to break apart the mountain. The dirt and rock that is removed is called spoil. MTM damages freshwater aquatic ecosystems and the surrounding environment by burying streams and headwaters with excess spoil. The
headwater is where water in the river or stream originates. MTM operations are used widely across southern Appalachia and are most abundant in southern West Virginia, eastern Kentucky, and eastern Tennessee (EPA, 2010). This project will focus on MTM in West Virginia (WV) and the Appalachia region.

MTM is comprised of several different steps. First trees and vegetation, as well as layers of rock and topsoil above the coal, called overburden, are removed. Trees are usually leased to a timber company to be logged and sold. The overburden should either be saved or spread over an existing stripped site. Next the area is prepared for pre-stripping using shovel loader and dump trucks and an area is pre-stripped to make a foundation for the dragline. The dragline is the most crucial piece of machinery for MTM because it digs and removes the coal. Access roads are constructed to reach the operation. The subsoil and rocks are drilled, blasted, and removed. Draglines excavate lower layers of coal with spoils placed in spoil piles. Re-grading begins as coal excavation continues. Overburden is either used in re-grading or placed into a valley fill. Once coal removal is complete, final re-grading takes place and the area is re-vegetated.

Mining operations are regulated under the Clean Water Act (CWA) including the discharge of pollutants into streams from valley fills (EPA, 2010). Coal mining processes are also controlled by the Surface Mining Control and Reclamation Act (SMCRA) of 1977 (EPA, 2010). The National Environmental Protection Act (NEPA) was passed in 1970 in order to monitor the environmental impact of federal agency actions and decisions. NEPA was designed to ensure that information about environmental impacts is available to public officials and citizens before government decisions are made. It requires environmental impact statements (EIS) and public input of environmental concerns for federal agency decision-making on projects such as MTM.
The key federal agencies that oversee MTM are the Office of Surface Mining Reclamation and Enforcement (OSMRE), U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (USACE/Corps). Other agencies involved include the Fish and Wildlife Service (FWS), Department of Environmental Protection (DEP), State Health Departments, The Centers for Disease Control and Prevention (CDC), and the Agency for Toxic Substances and Disease Registry (ATSDR).

There are two permit programs required to expand or build a new mining site. The first is the National Pollutant Discharge Elimination System (NPDES) program, administered by EPA under CWA Section 402. This permit controls discharge from sediment ponds, on-site coal preparation facilities, and storm water discharges from the mine site. Second is the dredge and fill permit program administered by the U.S. Army Corps of Engineers under CWA Section 404. This permit regulates discharge of mining overburden into waters of the United States.

Over the last 40 years, there has been an increase in MTM. The energy crisis of 1970s created an boost in the widespread demand of MTM. Throughout the 1980s, forty-four permits were granted covering 9,800 acres in contrast to 2002 where permits covering 12,540 acres were granted in only 9 months. Also during the 1980s the introduction of the dragline excavator, which can be as tall as twenty stories high in MTM operations, allowed for the faster removal of coal. Also, MTM experienced further expansion in the 1990s when the government amended the Federal Clean Air Act to include a stricter emissions standard. This increased the demand for the low sulfur, high volatility coal in West Virginia. MTM is also a quicker, cheaper method of coal mining than other practices. As MTM operations increased, a subsequent rise in lawsuits created a demand for government accounting of MTM impacts. As courts try to determine how existing environmental statutes apply to MTM operations, the regulatory framework is shifting.
The changing regulatory atmosphere was exemplified in 2010 with the EPA’s veto of the Spruce No.1 mining permit. The Corps initially issued the permit for the project, however operation was limited and delayed by litigation regarding the extent of environmental impacts it posed. The Spruce No. 1 mine is largest surface mining operations ever authorized in Appalachia. The EPA’s veto determination was based on the conclusion that the project could result in unacceptable adverse impacts to wildlife and fishery resources. The mine would directly impact 2,278 acres of forestland, degrade water quality in streams adjacent to the mine, and waste disposal would bury over seven miles of streams. The veto was the 13th 404(c) action in EPA history, the first post-permit 404(c) action, the first 404(c) protecting headwater stream ecosystems, and the first veto addressing surface coal mining. Thus, governmental enforcement and regulation of MTM in order to mitigate the practice’s adverse environmental impacts is growing.

Nevertheless, industrial and political opposition to tighter environmental safety regulations remains high. The mining industry hold major political power in Washington through hefty campaign contributions to GOP lawmakers and expensive lobbying efforts aimed at blunting the impact of environmental and safety-related legislation. Mining companies sharply increased their lobbying efforts tripling spending from $10.2 million in 2004 to nearly $31 million in 2008. Much of this spending went toward defeating cap and trade legislation. Additionally, the NMA reported spending $3.2 mil on lobbying in 2010, a portion of it to oppose Rep. George Miller's bill, which aimed to improve mine safety after 29 workers died in the Upper Big Branch mine explosion in April 2010. Furthermore, in 2004, Massey Energy’s chairman contributed $3 million to the campaign of a West Virginia judicial candidate, who later
played a pivotal role in overturning a $50 million judgment against the corporation. Overall, the mining industry made $6.4 million in political donations in the 2010 cycle.

In the past, mining was a source of economic advantage. Regionally, coal mining is a key component of the economy providing jobs and tax revenue which funds schools and other public resources. Almost all of the electricity generated in the area comes from coal-fired power plants. Although coal production remains high, machinery and new technology have reduced the need for coal miners. Consequently, unemployment, poverty, and out migration in the area are above the national average. Communities that flourished in the past have turned into ghost towns with empty storefronts and few economic prospects. With the environmental destruction of MTM becoming increasingly evident in WV, government leaders are turning to other sources of economic growth. For instance, tourism has become one of the most promising new pathways for economic development. Nonetheless, the coal industry will always have a major presence in WV due to the world’s relentless energy consumption.

In addition to the environmental and socioeconomic impacts of MTM, the health effects of MTM on the surrounding populations have yet to be addressed. Research regarding the health impacts of MTM is limited, but there have been several studies that suggest a link between coal mining and adverse health outcomes. For instance, one study linked higher risk of cardiovascular disease with air and water contamination consistent with toxicants found in the coal mining process (Hendryx & Zullig, 2009). Other studies have found relationships between cancer mortality in heavy coal mining areas as well as increased rates of kidney and respiratory diseases (Hitt & Hendryx, 2010). The studies that have been done are ecological studies based on county level data and self-reported. There are currently no studies analyzing individual level data. Thus the current literature base is limited by exposure misclassification bias, the ecological fallacy,
and recall bias. However, the studies do provide weak evidence of an association between human health risks and mountaintop mining and warrant future research efforts.

Although MTM produces a large proportion of coal necessary to fuel the nation’s energy demands, there are many adverse effects of MTM. The negative impacts of MTM include environmental devastation, socioeconomic effects on the surrounding communities, and jeopardizing human health. Furthermore, mountaintop removal can crack the walls and foundations of nearby homes, cause noise, dust, and vibration from blasting, and collapse drinking water wells. MTM has also destroyed nearby streams for fishing, hiking, foraging, swimming and aesthetic pleasure. It has even forced the relocation of whole communities. For example Massey Energy bought out the entire town of Lindytown in Boone County, West Virginia forcing people to relocate from the area so a new mine could be built.

As a result of the impacts of MTM on community members, the obvious ecological devastation it causes, and part of a legal settlement requirement, several government agencies collaborated to investigate the environmental impacts of MTM. The agencies included the U.S. Army Corps of Engineers (COE), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Interior’s Office of Surface Mining (OSM) and Fish and Wildlife Service (FWS), and the West Virginia Department of Environmental Protection (WVDEP). They conducted or funded over 30 environmental impacts studies of mountaintop mining and associated excess spoil disposal valley fills (VF). The findings of these studies were used by the organizations to develop a Final Programmatic Environmental Impact Statement (FPEIS) in order to reduce the adverse environmental impacts of MTM/VF operations.

The EIS was created to “consider developing policies, guidance, and coordinated agency decision- making processes to minimize the adverse environmental effects to waters of the
United States and to fish and wildlife resources affected by mountaintop mining operations, and
to environmental resources that could be affected by the size and location of excess spoil-
disposal sites in valley fills within the Appalachian study area in West Virginia, Kentucky,
Virginia, and Tennessee” (EPA, 2005). After seven years of research and evaluation, the
agencies finalized the FPEIS. The summarized findings of the FPEIS indicated that “streams in
watersheds where MTM/VF exist are characterized by an increase of minerals in the water as
well as less diverse and more pollutant-tolerant macro invertebrates and fish species” (EPA,
2005). Studies for the FPEIS also found that between 1992 and 2002 approximately 1200 miles
of headwater streams were directly impacted by MTM/VF features including coal removal areas,
valley fills, roads, and ponds, and from 1985 to 2001 an estimated 724 stream miles were
covered by valley fills (EPA, 2005). Overall, the FPEIS highlights many of the adverse
environmental impacts of MTM in regards to water pollution, however the impacts of MTM on
air quality is not as well studied.

The government does not currently regulate air pollution from MTM because scientific
research is insufficient for developing and enacting legislation. One study conducted in Roda,
Virginia through the collaborative efforts of the Sierra Club and North Carolina State University
assessed roadside dust exposure. In this area residents live within 50ft of roads with heavy flows
of truck traffic carrying loads of uncovered coal during the day and night. The ATSDR evaluated
data and concluded the levels are likely to be of health concern with concentrations reaching up
to 469 µg/m\(^3\)/24 hour period, well above NAAQs standard of 150 µg/m\(^3\)/24 hours. The ATSDR
concluded that the air quality was likely to be of concern and compromised the health of
individuals living in this area especially because of the intermittent peak periods of dust during
high production and dry conditions. Research is beginning to uncover the extent of
environmental damage and pollution caused by MTM through air and water exposure routes yet the threat of those exposures on human health has yet to be determined. Therefore, creating a Health Impact Assessment (HIA) to evaluate health risks posed by MTM and create policy recommendations to mitigate those risks is necessary.

An HIA is similar to an environmental impact assessment (EIA). The National Environmental Policy Act (NEPA) requires federal entities to evaluate the environmental impact of their proposed actions on social, cultural, economic, and natural resources prior to implementation. These potential actions include projects, programs, plans, or policies. Unlike an EIA, an HIA can be a voluntary or regulatory process that focuses on health outcomes such as asthma, heart disease, cancer, hearing loss, psychological disorders, and increased mortality rates. HIAs also assess environmental justice, socioeconomic and social equity issues. HIAs have been incorporated into EIA processes to assess potential impacts to the human environment. This HIA will assess the health impact of MTM on WV communities.

Health Impact Assessment

According to the World Health Organization (WHO), a Health Impact Assessment (HIA) is a “practical approach used to judge the potential health effects of a policy, program or project on a population, particularly on vulnerable or disadvantaged groups” (WHO, 2010). The goal of an HIA is to produce recommendations for the stakeholders and decision makers that maximize the positive health effects and minimize the negative health effects of a proposal. An HIA is comprised of four values: democracy, equity, sustainable development, and ethical use of evidence (WHO, 2010). Democracy allows public participation in the growth and execution of policies and projects that may affect their lives. Equity refers to the comprehensive evaluation of the distribution of impacts that a proposal has on an entire population while emphasizing
vulnerable populations. HIA makes certain that proposals do not accidentally damage health or reinforce disparities. The sustainable development aspect of a HIA requires that short and long term effects as well as subtle and obvious impacts of a policy be considered. The ethical use of evidence in a HIA ensures that the best qualitative and quantitative evidence is identified and used in the assessment. These values provide a constructive developmental environment for the proposed policy or project.

HIA is extremely influential in the initial stages of policy development allowing the most time to inform policy makers of the health aspects of an issue such as MTM. Also, an HIA can be prospective which may prevent damage by proposed activities from occurring in the future. HIA can stimulate awareness of policy makers to consider health impacts and quality of life aspects of proposals on the well being of local communities. Moreover, HIAs encourage participants from multiple sectors to collaborate because public health and safety is determined by various economic, social, and environmental influences. HIA also takes into account community perspective ensuring that decision makers are aware of public opinion and will represent them in the policy. It provides a route of engagement and communication between affected members of the community and the organization enacting the project. HIAs provide information to decision makers in a clear transparent way in order to help enact effective policies.

Environmental Justice

Environmental Justice (EJ) has recently been made a priority at the EPA especially for mountaintop mining because many of the residents surrounding mining activities are politically disenfranchised and economically incapable in having a say in what goes on in their community. Evaluation of the EJ aspects of MTM is necessary in order to assess whether or not there are
disproportionate impacts of the mining process on these disadvantaged populations. The EPA defines environmental justice as “the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies” (EPA, 2010). The communities surrounding MTM sites are often of low socio-economic status (SES) and lack educational attainment placing them at risk of facing disproportionate effects of the mining industry. Executive Order 12898 states that “each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States.” In accordance with the executive order, the EPA has recently made EJ a high priority and is taking action to address the EJ impacts of MTM in Appalachia. EJ is an essential element for the analysis of MTM and human health and is thoroughly evaluated in the HIA.

**Theoretical Framework**

Social Ecological Model (SEM) provides the most appropriate theoretical framework for creating a Health Impact Assessment of mountaintop mining. The idea behind the ecological model is focused attention on both individual and social environmental factors as targets for health promotion interventions (McLeroy, Bibeau, Steckler, & Glanz, 1988). The SEM addresses the importance of interventions directed at changing interpersonal, community, organizational, and public policy factors which nurture and uphold unhealthy behaviors (McLeroy et al, 1988). This is pertinent for the topic of mountaintop mining where interpersonal interactions at different levels of society are a large component of what influences the health beliefs and behaviors of community members. For instance, policy making for MTM is influenced by scientific evidence,
community organizations, industries, and government agencies. These policies then in turn influence the community members living near MTM operations as well as the companies that own the mining sites.

In the interest of environmental justice, the SEM is highly applicable. The model asserts that appropriate changes in the social environment will produce changes in individuals, and that the support of individuals in the population is essential for implementing environmental changes (McLeroy et al, 1988). This is relevant for environmental justice aspects of mountaintop mining where the economical status of the communities influences their susceptibility to the establishment of mining sites. Additionally, the model examines intrapersonal interactions such as cultural, biological, and relational levels within societal and organizational frameworks, which can also apply to the EJ aspects of MTM. For instance, the EPA OECEJ is working to build a positive relationship with community leaders in order to disseminate information regarding the risks of MTM and the rights of the individuals to protect their health and safety. Community members in turn provide information about the infrastructure and resources available to the residents such as health clinics, schools, waste treatment facilities to help the OECEJ address areas of need and concern.

Thus, considering the multi-level nature of interactions between individuals, communities, and the organizational environment involved in mountaintop mining, the social ecological theoretical framework is best option for developing public health interventions.

**Literature Review**

A review of existing literature on the human health impacts of MTM was attempted to establish the baseline scientific understanding of MTM community health risks. Unfortunately, there are no completed studies on MTM and human health. Thus, the majority of research
analyzed in this literature review evaluates the relationship between traditional coal mining, not MTM, and human health. Nonetheless, examining the available literature is valuable for understanding potentially relationships between exposure and disease, as well as designing future studies.

The region of Appalachia is generally characterized by social inequalities and health disparities (Hendryx, 2008). The inequalities and disparities experienced by communities due to coal mining have become a major focus of public health agencies such as the U.S. Environmental Protection Agency (EPA). Additionally, numerous environmental contaminants associated with coal extraction and processing are known to contribute to cardiovascular disease (CVD) including toxic metals such as arsenic and cadmium, particulate matter (PM) and polycyclic aromatic hydrocarbons (Hendryx & Zullig, 2009). All of these factors have influenced and warranted the scientific evaluation of coal mining on human health.

Coal mining areas are typically of lower socioeconomic status (SES) relative to non-mining areas, and coal mining states such as West Virginia have lower SES overall than the U.S. average (Hendryx, 2008). Additionally, lower SES has long been correlated with higher disease incidence, prevalence and poorer health outcomes across the spectrum of diseases particularly chronic conditions, such as diabetes, heart disease, and cancer and recent studies have suggested that in Appalachia environmental pollution from the mining industry is a contributing factor (Hendryx & Ahern, 2009). For example, Hendryx and Ahern (2009) found that age-adjusted mortality rates were higher every year from 1979 through 2005 in Appalachian coal mining areas than non-mining areas of Appalachia or the U.S. They also found that the highest mortality rates were associated with areas having the highest levels of mining activity (Hendryx & Ahern, 2009).
Another factor that may contribute to the higher mortality levels is elevated stress caused by economic disadvantage and environmental degradation. Adjusted mortality rates were found for both males and females eliminating occupational exposure as the key explanatory factor (Hendryx and Ahern, 2009). Low socioeconomic status was found to be a significant factor in morbidity and premature mortality, and the higher unemployment and poverty rates in coal mining regions of Appalachia is likely a contributing factor to the region’s poor health (Hendryx and Ahern, 2009). The heaviest coal mining areas of Appalachia had the poorest socioeconomic conditions (Hendryx and Ahern, 2009).

Before adjusting for covariates, the number of excess annual age-adjusted deaths in coal mining areas ranged from 3,975 to 10,923, depending on years studied and comparison group (Hendryx & Ahern, 2009). Areas with heavy mining have the highest unemployment rates in the region and coal mining counties in West Virginia experienced a mean net loss of 639 people to out migration between 1995 and 2000, compared with a mean net migration gain of 422 people in non-mining counties (Hendryx and Ahern, 2009).

Among West Virginia adults, residence in counties with mining operations was associated with poorer health status and higher risk for cardiopulmonary disease, chronic lung disease, hypertension, and kidney disease, after controlling for covariates (Hendryx & Ahern, 2008). This study evaluated self-reported health indicators that were not confirmed by medical records and had a very low participation rate. However, it still suggests directions for further research.

Hendryx and Zullig (2009) conducted a study in to compare CVD rates for men and women residents of Appalachian coal mining counties before and after controlling for covariates. The CVD was self-reported in this study and not confirmed by medical records. Also, the participants are a survivor population and may not necessarily represent the exposure and
covariate experience of those who did not survive CVD. This study used national Behavioral Risk Factor Surveillance System (BRFSS) data to assess CVD risk in coal mining areas and incorporated important CVD covariates such as alcohol consumption, diabetes, obesity, and smoking. The results were that people in mining areas have higher risk of cardiovascular disease (CVD) (OR=1.22, 95% CI 1.14-1.30), angina or coronary heart disease (CHD) (OR=1.29, 95% CI=1.19-1.39), and heart attack (MI) (OR=1.19, 95% CI = 1.10-1.30) after adjusting for smoking, alcohol, gender, education, race, income, physician supply, and metropolitan status (Hendryx & Zullig, 2009).

Hendryx (2009) related county-level, age-adjusted mortality rates for the years 2000–2004 for heart, respiratory and kidney disease to tons of coal mined and found that total chronic heart, respiratory, and kidney disease, and kidney disease mortality rates were significantly higher in coal mining areas of Appalachia than non-coal mining areas for males and females. The study used Poisson regression models and included covariates of percent male population, college and high school education rates, poverty rates, race/ethnicity rates, primary care physician supply, rural-urban status, and smoking rates.

Cancer mortality is high relative to the U.S. in West Virginia and parts of Appalachia and has been linked with behavioral risk factors, such as smoking, associated with poor socioeconomic conditions (Hendryx, Fedorko, & Anesetti-Rothermel, 2010). Here again, coal mining activities potentially contribute to the elevated cancer rates. As noted by Hendryx (2008) and Hendryx and Ahern (2009) persons living in coal mining counties of Appalachia have elevated rates of total mortality and lung cancer mortality, after controlling for socio-economic status, availability of health care and other behaviors. Mining processes have contaminated trillions of gallons of water and released tons of particulate matter into the air in mining
communities and it is known that coal contains many established carcinogens such as arsenic, cadmium, chromium, nickel, and beryllium (Hendryx, Fedorko, & Anesetti-Rothermel, 2010). Distance-weighted, at-risk population coal mining exposure measure was significantly correlated to cancer mortality in WV for total cancer and 3 subgroups after controlling for smoking rates and this held for all components of mining processes (injection, preparation plants, impoundments, and mining sites) (Hendryx, Fedorko, & Anesetti-Rothermel, 2010).

Although the investigators of this study used distance weighting, they aggregated this data to the county level and combined these processes into a single index for the regression analyses. This reduced the values of distance weighting and removed the opportunity to evaluate each mining process separately in the regression analyses. Also, they use OLS instead of a weighted or Poisson regression method. Nonetheless, the study is still warrants further research.

As noted previously incidence and mortality of cancer and other diseases in Appalachia is generally thought to result from higher smoking rates and associated low socioeconomic conditions and behaviors. Elevated arsenic levels in drinking water sources in coal mining areas have been found in areas of central Appalachia. Elevated lung cancer mortality rates largely attributed to smoking and socioeconomic factors may also be caused by exposure to environmental contaminants associated with mining processes. Hendryx, O'Donnell & Horn (2008) investigated whether elevated lung cancer mortality in Appalachia is attributable to strictly smoking and socioeconomic factors or whether an additional effect associated with proximity to heavy coal-mining areas is a contributor.

The Hendryx, O'Donnell & Horn (2008) study found that lung cancer mortality is higher in heavy coal-mining areas, followed by all other areas of Appalachia and the nation (p<.001) after accounting for covariates of gender, education, poverty, race, urban status, smoking,
southern states, and Appalachian country. Additional studies have found that volume of coal mining is significantly related to hospitalization risk for hypertension (odds increased 1% for each 1462 tons of coal) and chronic obstructive pulmonary disease (odds increased 1% for each 1873 tons of coal) controlled for age, gender, insurance, co-morbidities, county poverty, county and social capital (Hendryx, Ahern & Nurkiewicz, 2007).

Another study found that residence in counties with mining operations increases the odds of low birth weight. Specifically, in mining areas odds of low birth weight are increased by 14 to 16% depending on the amount of mining as compared to areas with no coal mining (Ahern, Mullett, MacKay, & Hamilton, 2010). There was no confounding by maternal risk factors such as smoking, education, prenatal care, or age in this study. A final study showed that ecological integrity was inversely related to age-adjusted cancer mortality rates (total p<.01; digestive, breast, and respiratory p<.01; urinary p<.05), controlled for poverty, access to health care providers, urbanization, education, smoking and that mining was significantly related to total cancer mortality (Hitt & Hendryx, 2010).

These studies provide weak evidence for a causal link between MTM and elevated rates of adverse health effects. Many of the studies reviewed were ecological, utilized crude ecological exposure variables, and were conducted using secondary data. They do not provide direct assessments of environmental air and water quality in mining areas in relation to individual exposures and health outcomes. Still, the results warrant further research using rigorous epidemiological methods. In order to take into account the variability in disease rates across counties, due to difference in population size, researchers should use a weighted regression approach or Poisson regression. They would also need to check for over dispersion in those analyses that could be due to disease rate correlations among adjacent counties.
Additionally, more comprehensive research, including environmental chemical analyses and biomonitoring, would require significantly greater funding. Yet, given the long latency periods associated with most of the diseases of interest, conducting dispersion modeling and historical exposure reconstruction rather than biomonitoring may be more appropriate. If priority lies with removing current exposure sources, then biomonitoring may be necessary. However, the results of these associational studies are sufficient to identify significant correlations between MTM activity and a variety of health disparities. Study findings indicate that health disparities are elevated in Appalachian coal mining regions for a number of common diseases including cardiovascular disease (CVD) and lung cancer. Risks for these diseases are affected by many factors including lifestyles, health-related behaviors and the cultural influences, genetic predispositions, environmental exposures, and lower socioeconomic status (SES).

The existing body of literature suggests that various negative health outcomes are not the result of a single exposure, but may reflect chronic exposures to multiple environmental pollutants, both air and/or water, which will vary for each individual. Future research on MTM faces the challenge of addressing the many confounders that are involved in assessing health effects and strength of associations to MTM. However, it is rare for a significant confounding to occur in a study because the covariate must be a strong risk factor for the disease of interest and have at least a moderate association with the exposure of interest. Even for smoking-related diseases, smoking will not be a confounder unless it has at least a moderate association with MTM exposure. So it is very likely that there will not be many confounders that will have a significant impact on a MTM exposure-disease relationship at the individual level. On the other hand, exposure misclassification is likely to be an important bias.
Given the high level of concern about overall environmental and human health effects from mountain top mining (MTM) and the increasing focus of federal agency decisions to review and either approve or disapprove mining permits, the existing literature base is inadequate. Rigorous primary research needs to be conducted in order to develop the level of relative certainty decision makers will need to disapprove permits or require pollution reduction measures to protect health.

**Specific Aims**

The aim of this project was to evaluate the impact of Mountain Top Mining (MTM) on communities in West Virginia (WV). A HIA is being created based on extensive research and evaluation of MTM. The values of equity, democracy, sustainable development, and ethical use of evidence were upheld during the development of the HIA. Another key component of this project was evaluating and understanding the epidemiology of MTM in WV. EJ issues are also being extensively addressed. The three major aims of this project are described below.

- **Aim 1- Create a Health Impact Assessment of MTM in accordance with WHO guidelines**

  An HIA is created through six main steps. The first step is screening, which involves identifying projects or policies for which an HIA would be useful. MTM is the project of focus for this HIA. The second step in an HIA, scoping, identifies the specific health effects for consideration. The scope of the MTM HIA will include cardiovascular, respiratory, and kidney disease, as well as various cancers. Next, creating an HIA involves assessing risks and benefits and identifying who is affected and how they are affected. Communities in WV will be the population of focus in this HIA. The fourth step in the HIA process is developing recommendations and suggesting changes to proposals to promote positive or mitigate adverse health effects. After thorough evaluation of
information about MTM recommendations will be made in the HIA. Then this information will be reported to decision makers in the EPA Region 3 department. Finally, the affect of the HIA on the decision evaluated and established.

- Aim 2- Determine the specific Environmental Justice components of MTM
- Aim 3- Propose study designs and approaches to address gaps in science, and recommend effective interventions and programs using the current knowledge base.

**Research Design and Methods**

**Overview**

This project is a policy analysis of the most recent scientific evidence regarding the human health impacts of MTM and the feasibility to create public health interventions.

**Methods of Data Collection**

**Methods for Aim 1**

A thorough literature review and program review was conducted in order to fulfill the requirements of a Health Impact Assessment for Mountaintop Mining under Centers for Disease Control and Prevention guidelines. The Drexel University Library database was utilized to find primary and secondary sources for the literature review. Specific databases included Pub Med (Medline), Science Direct, and MEDLINE via OVID. Additionally resources available internally at the EPA Region III were relied upon for the literature review.

Multiple meetings with key stakeholders for MTM in the EPA took place and served as additional resources for development of the HIA. Stakeholders included representatives from the Agency for Toxic Substances and Disease Registry (ATSDR), the EPA Office of Enforcement, Compliance and Environmental Justice (OECEJ), and members of academia. Academic
institution involved included Duke University and West Virginia University. National policies, regulations, and programs on MTM were also evaluated. Health characteristics and rates of disease were also collected and analyzed for the Boone County region.

**Methods for Aim 2**

Executive Order 12898 was reviewed as a guideline for the Environmental Justice investigation of this HIA. The EJ assessment included meetings with OECEJ officials, a literature review, an analysis of Census data, and an evaluation of activist/advocacy groups centered on MTM. Information from a personal visit to West Virginia mining communities and Mountaintop Mining sites provided additional insight regarding the EJ issues in the area. Public documents, notices, and hearings relating to the human health impacts of MTM were reviewed for the HIA.

**Methods for Aim 3**

Future study designs and interventions were based on an evaluation and critique of current literature by CDC officials and through the examination of current and prospective EPA Cumulative Impact Assessment projects. The different MTM projects of the EPA’s Environmental Assessment & Innovation Division were reviewed along with ongoing Environmental Justices programs in the Region III office.

**Human Subjects Considerations/Institutional Review Board Approval**

Human subjects were not involved in this project. An International Review Board Release Letter was submitted for approval on November 4th, 2010 and was confirmed on November 9th, 2010 by the Drexel University College of Medicine Office of Regulatory Research Compliance.
Results

Currently, the EPA, OSM, Corps, and FWS are conducting a Cumulative Impact Assessment to collaboratively address all MTM impacts and develop better prediction tools by creating a framework that will facilitate decision-making under complex conditions, diverse societal values, and multiple regulatory situations. They aim to (1) clarify and strengthen the epidemiological evidence base for health impacts from mountaintop mining (2) build, maintain and sustain in-house capability to do integrated modeling, decision analysis and uncertainty analysis for Region III applications such as cumulative impacts assessment (3) quantify links between mining, wildlife habitat, water quality and aquatic communities and identify associated mining thresholds that produce ecological impairment downstream.

The agencies chose the Boone County, part of the Coal River Watershed, to focus their assessment comparisons effort because the area is extensively mined, data on water quality and aquatic biology is available, there is an EJ component, and EPA previously conducted research in this watershed on aquatic health effects of mining. The agencies are trying to build a comprehensive framework to facilitate decision making to approve mining permits and assess additional impacts to aquatic life and human health of new or expanded mines. Accordingly, the results, statistics, and data collected in this project represent and describe the population of Boone County.

Results for Aim 1

The EPA and CDC attempted to collect detailed data for cancer, asthma, and blood lead levels, but they were only available at county level. Because of the scale of available data there was limited opportunity to contribute to the existing body of literature and further refine those analyses. Thus, the HIA was accomplished through the analysis of a thorough literature review, local data evaluation, and broad stakeholder consultation. The Health Impact Assessment entitled “Assessing Health Impacts of Mountaintop Mining: Protecting Public Health in Appalachia” is
located in Appendix A. The main goal of this health impact assessment was to establish the health risks of a practice such as mountaintop mining and create recommendations for policy makers to reduce these risks. This was challenging due to the limited number of studies on the health impacts of coal mining. There are currently no completed human health studies of MTM impacts. The studies that have been done found serious and persistent health problems for residents who lived near coal mining activities. These health problems included higher death rates for all cause mortality and for death from heart disease, lung disease, kidney disease, and cancer. Studies also showed higher self-reported rates of many chronic illnesses including heart, lung and kidney disease, as well as higher rates of low birth weight babies. Although these studies provide evidence of an association between MTM and human health risks, they have many limitations.

None of the studies specifically address MTM activity and most were based on deep coal mining exposures. Self reported diseases were not confirmed with medical records raising concern for recall bias and information bias. Additionally, studies were mainly ecological, thus variables did not adequately address individual level confounding. Despite these limitations, the compiled literature shows limited/weak evidence for various human health impacts of coal mining exposure including heart, lung, and kidney disease and certain cancers. The evidence is sufficiently strong to warrant further research with better defined exposures and individual level covariate and health data.

**Results for Aim 2**

General information about the epidemiology of the Appalachia region was collected for the HIA to evaluate the environmental justice component of MTM. This information has illuminated the disproportionate impacts on communities living near MTM sites compared to the general population. Mining inherently creates environmental injustice because the initial mining footprint plan is the only one that receives feedback from community members. These footprint plans change over time and community input becomes irrelevant. Additionally, MTM companies
are required to hold opportunities for public comment on plans for new mine development. The community is able to add their input and concerns regarding new mining operations. However, even when communities have meaningful involvement the mining companies continue to manipulate them. For instance, mining companies transport employees to public meetings creating a deceiving amount of supporters for new mining project and smothering potential opposition by community members. Other impediments to ensuring a fair, well informed process of building new mining sites include the political influence of the mining companies who use financial means to influence the decisions of political officials.

In addition to the inherent environmental justice issues involved in mountaintop mining, analysis of the demographic and economic characteristics of Boone County, West Virginia has shown other areas of EJ concern. For example, the family poverty level of Boone County is 15.5%, higher than West Virginia and national levels of 13.2% and 9.9% respectively (US Census Bureau, 2009). Mining companies choose to establish operations where there is little competition from other industries and where workers are dependent on them for income. The high poverty rate of Appalachian communities confirms one of the many environment justice components of MTM.

Other EJ-related issues in communities were identified including limited sanitation and sewage disposal resources, reported trash burning in yards, and destruction of their rich natural and cultural heritage. There are also high levels of smoking with 26.5% of West Virginians were smokers compared to 18.3% of the U.S. population (CDC, 2009). The unemployment rate for West Virginia is 9.7%, above the national level of 9.1% (U.S. Census Bureau, 2011). However unemployment in Boone County is 8.2%, which could be attributed to high amounts of mining creating jobs in this area (U.S. Census Bureau, 2011).
Residents of Boone County also lack of educational attainment with only 8.0% of residents receiving a bachelors degree or higher compared to 27.5% nationally and 17.1% in West Virginia (Census, 2009). Residents in the areas impacted by MTM have insufficient educational opportunity to become informed about the potential risks of industrial practices that infiltrate their communities. Thus they are unable to advocate for their rights and make informed input when mining companies hold public meetings to discuss concerns over expanding MTM operations. A more comprehensive environmental justice analysis is included in the HIA. My personal visit to West Virginia mining communities also provided insight into the environmental justice issues of MTM.

**Results for Aim 3**

There are several federal and academic efforts underway to evaluate the human health and EJ impacts of MTM, which will hopefully create a gateway to enact legislation and policy to ameliorate adverse impacts on communities of WV. The Cumulative Impact Assessment in progress at the EPA is composed of several projects that are currently getting off the ground. These include an air exposure modeling project, Action plans to address environmental justice, and expanding the current epidemiologic knowledge basis.

The EPA’s air modeling study will be assessing the impact of various types of air pollution caused by MTM sites on exposed populations. The team is constructing an emissions inventory for each of the many sources related to the mining operation and for the haul truck traffic (emission rates with their associated temporal & special variability). The will characterize each of the sources as point, area, volume, open pit, instantaneous release from blasting. Next they will execute the air quality modeling approach to estimate the air pollutant concentration fields that result from MTM operations. Finally, population and public health impacts at the local
level impacts will be determine from: (1) the estimated concentration fields (2) a characterization of the population in the vicinity of the mining operation and (3) the use of an appropriate exposure model.

A Duke University study by Dr. Marie Lynn Miranda will look at public health impacts of MTM activity levels related to drinking water with two different projects. First her team will be compiling data on private wells, water quality, and potentially affected water resources in order to tie contaminants from well water to mining sources. Some of the elements they will be measuring include Selenium, Arsenic, Mercury, Lead, and Manganese. They want to assess how much mining activity is going on, where it is occurring and the distance injection sites and impoundment ponds are from homes. The second project involves linking potentially affected water resources/environmental variables that derive from MTM activities with vital birth and death records from West Virginia.

One of the ways the EPA is addressing the adverse EJ effects experienced by the WV communities is with the MTM Action Plan created by the Office of Enforcement, Compliance and Environmental Justice (OECEJ). The Action Plan consists of listening sessions, community site tours, and on-going dialogue with citizens from Appalachia. Citizens have cited issues such as loss of cultural heritage, losing family cemeteries buried by rubble, and coal companies closing county access roads. Residents have also voiced concern for and loss of drinking water sources, mud slides and land disturbances. They also mentioned anxiety about truck traffic, air quality, toxic contamination, and intimidation from the coal companies. The goal of the Action Plan is to gain a better understand issues and concerns associated with MTM and develop relationships with people in the communities.
The OECEJ is also creating community characteristics packets for EPA internal use that will include different types of data and information gathered through the Census. The OECEJ is currently working on updating Census 2000 data with 2010 data. This data includes poverty levels, racial diversity, housing, plumbing, and heating access. The OECEJ is also trying to acquire missing data on the location of private drinking water wells and resident who do not use water from the municipal water system. This is important because no testing is done on private drinking water wells to ensure that the water is uncontaminated. Often in these areas of Appalachia, people in the community cannot afford to regularly test their wells. The OECEJ is gathering this data for the community in order to provide them with a meaningful opportunity to make informed comments on MTM environmental impact statements and during public meetings. This also includes disseminating information about new mining permits.

Lastly the OECEJ is mapping structures in the area of Boone County to understand resources in the community. Structure of interest include health clinics, schools, gas stations, dental offices, post offices, churches, libraries, and police stations to name a few. OECEJ officials plan to use the relationships built with community members to learn about the infrastructure of the surrounding areas. EPA plans to disseminate information through community activist groups and other organizations, churches, public meetings. Future actions could involve listening sessions throughout mining communities to discuss EJ issues with communities and provide education about the MTM regulatory process, heath risks and their political rights.

The EAID recently sent a formal request to the CDC for assistance in getting approval and funding to conduct a study on the human health impacts of MTM. EPA would like to develop a more scientifically defensible, evidence-based foundation on the connections between
mountain top and surface mining and human health. EPA plans to use this foundation to evaluate health impacts from ongoing and new mining activities, and to serve as the basis for defining acceptable conditions in reviewing mining permits and activities. To meet these objectives, EPA Region III is formally requesting epidemiological technical assistance from the Agency for Toxic Substances and Disease Registry and the National Center for Environmental Health of the Centers for Disease Control and Prevention.

EPA Regions 2,3,4, and 5 have undertaken a Regional Ecosystem Services Proposal where they will assess lost ecosystem services as a result MTM/VF in the Appalachia Region. They will address the loss of two high priority ecosystem services, drinking water and recreational fisheries, in selected communities, relevant to mining in Kentucky, West Virginia, and Southeastern Ohio. This project will involve the synthesis of existing data to demonstrate the impacts of MTM/VF on ecosystem structure and function and an economic assessment of the loss of those two ecosystem services. They are utilizing a novel decision support tool, scalable to different geographic levels, to enable a prediction of broader scale ecosystem services losses.

**Discussion**

Mountaintop mining is a highly controversial practice due to the environmental devastation it causes in order to extract coal, one of the nations most valuable natural energy resources. Consistent with other large-scale industrial operations, regulating MTM has not been an easy task. Initially, MTM was not tightly monitored and regulations were not strictly enforced. Over the years, increasing amounts of litigation from citizens and environmental activist groups has led to a larger effort in researching and evaluating the environmental impact of MTM. These initiatives have helped shape the current, more stringent environmental regulations of MTM. Yet, there is insufficient research regarding the human health risks of MTM.
because quantifying exposures, determining exposure pathways, and accounting for covariates remains a challenge. This lack of scientific evidence hinders the implementation and enforcement of policies to mitigate human health impacts of MTM.

Government agencies such as the EPA are actively trying to establish and enforce the most effective regulations that will limit the adverse environmental and human health impacts of MTM. The MTM industry makes implementing and enforcing regulations difficult because it constantly refutes research and appeals the fines and penalties issued by enforcement agencies. Additionally, the mining industry contributes large amounts of funding influencing political leaders to favor legislation for less stringent environmental laws and regulations. They also use money to take advantage of and control communities by forcing them to relocate from their homes as well as by providing funding for schools and other public resources. As a result of the continuous power struggle between the EPA, academia, environmental activists, citizens, and the mining industry, understanding the human health impacts has not been a high priority.

In order to enact enforceable policies, the scientific basis for implementation must be concrete. Unfortunately, there are few studies involving the health impacts of coal mining, and the majority of these are ecological utilizing crude measures of exposure. They evaluate county level data and are subject to exposure misclassification bias. There are no human health studies of individual level data due in large part to a lack of funding. Moreover, existing studies do not isolate MTM removal and largely focus on total coal extraction. Existing data is not sufficient to establish the strength of association necessary to make agency decisions regarding human health risks.

There are many other factors that limit the scientific evaluation of the impact MTM on human health. Some of the reasons include that it is hard to measure the exposures of different
chemicals from MTM and the routes of exposure are highly variable. Analysis of the cumulative effects of chemical exposures must be accounted for as well. Additionally, measuring the exposures for individuals and linking them to a specific disease is very difficult. Many covariates such as smoking, occupation, diet, lack of municipal resources, physical activity levels, and socio-economic status must also be accounted for during analysis. Low population density in the areas of interest limits power (sample size) and the ability to conduct a valid study.

Additionally, communities can often oppose EPA permit restrictions and instead support MTM because of the economic benefits, job opportunities, and lack of education about the harm and risks of the practice. Some of the residents have signed non-disclosure agreements with the mining companies in exchange for resources such as water, which do not allow them to participate in research studies. This limits the number of study participants in these low populated areas even further. Thus, the HIA relied on the findings from existing studies of coal mining and human health risks, which can be extrapolated to represent similar health outcomes from MTM exposures.

After numerous meetings with OECEJ officials and extensive research, the environmental justice impacts of MTM on West Virginia communities such as Boone County are evident. Data show many characteristics of the mining communities that indicate injustice is occurring. According to the U.S. Census Bureau, socioeconomic status and per capita income are lower throughout WV versus the United States. Poverty rates are well above the national average and there are high unemployment levels throughout West Virginia. The communities are economically disadvantaged with minimal political voice and are unable to make informed comments regarding new/expanding mining operations. However, the low population density of
the rural areas where MTM is prevalent as well as acquiring data at the zip code level limits the reliability of Census and other sources data.

Addressing EJ issues and taking actions to reduce them is a challenging endeavor because improving the SES and access to municipal resources of these communities is not a realistic or feasible short-term task. The OECEJ is taking steps to understand the adverse circumstances these people face at baseline in order to prepare them to voice their concerns during public meetings and in environmental impact statements. OECEJ officials have limited power to improve the living conditions of communities surrounded by mining. Their actions are restricted to disseminating information about their political rights and potential health risks they face from MTM operations. They also are actively trying to build relationships with the community leaders in order to maintain communication.

Government officials face a difficult choice between protecting the health of citizens and the economic benefits of MTM for the region. Collaborative efforts of government officials are necessary to determine the health risks of MTM and establish regulations that protect the population while enabling mining activity to continue. Also, efforts to establish economic revenue from alternative sources such as tourism are necessary to protect the fragile economies of these communities while upholding their health and political rights.

Conducting scientific research is an integral factor for mitigating the health risks and adverse impacts of MTM. However, it requires large amounts of funding and willing study participants. The OECEJ’s efforts to foster relationships with mining communities will help increase outsider understanding of their cultural beliefs and attitudes in order to effectively disseminate information. Instead of feeling dependent on the mining industry, the knowledge and insight provided by the OECEJ will help residents work toward a more self-sufficient future. The
OECEJ efforts should highlight the benefits of scientific research and increase willingness to take part in health impact studies.

**Conclusion**

The multifaceted controversial nature of mountaintop mining makes policy implementation and public health interventions challenging. There is insufficient scientific evidence regarding the human health impacts of MTM, a necessary element in the policy development process. Policies must be formulated based on the most up to date scientific research in order to withstand litigation. The environmental justice component of MTM has been confirmed based on Census data and through evaluation of communities in WV. However, actions to ameliorate the environmental injustices that may impact MTM communities are not always taken by the corresponding federal agencies.

The MTM Action plan created by the OECEJ is one of the ways the EPA is addressing the adverse EJ effects experienced by the WV communities through education and information dissemination. Efforts should also be made to restore the natural and cultural heritage while improving the quality of life for MTM communities. This may stimulate the tourism industry and decrease the region’s reliance on the coal mining industry. Furthermore, there are several federal and academic efforts underway to evaluate the human health impacts of MTM, which will hopefully create a gateway to enact legislation and policy to ameliorate adverse impacts on communities of WV.

Based on the findings of the HIA, an epidemiological investigation of mining exposures and health impacts is imperative to develop the most effective policies that will protect the public health. Increased collaborative efforts must be made by government agencies such as the EPA,
CDC, and ATSDR as well as academic institutions to connect environmental impacts with the health risks posed by MTM.
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Appendix A. Assessing Health Impacts of Mountaintop Mining: Protecting Public Health in Appalachia
Assessing Health Impacts of Mountaintop Mining:
Protecting Public Health in Appalachia

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Abstract

A Health Impact Assessment (HIA) was created for Mountaintop Mining (MTM) in Appalachia, specifically for Boone County, WV. Public health is often not assessed in Environmental Impact Statements (EIS), thus an HIA was conducted in response to the growing concerns of residents and anecdotal evidence of increased health problems. The residents of Appalachia already face lower health outcomes than the rest of the United States due to their rural location and lower socioeconomic status, and the impacts of Mountain Top Mining add to this disparity. Using a combination of literature reviews, stakeholder input, permitting documents, and qualitative analysis we identified potential health effects. These include increased risk of lung cancer, heart disease, kidney disease, and mortality from heart attack. Mining also produces economic benefits, including tax revenue and employment opportunities. However the findings of the HIA suggest that the human health threats of MTM may exceed the economic benefits. Based on these findings, we recommend rigorous epidemiologic studies on the human health impacts from MTM exposure. The environmental impacts of MTM must be linked to human health impact. Developing policies based on strong scientific research are necessary to mitigate adverse health effects from MTM.
Screening

Mountaintop mining (MTM) was the chosen topic of interest for this health impact assessment (HIA) because its adverse environmental impacts have been established but potential human health impacts remain uncertain. As the occurrence of MTM increased, concerns of the environmental impacts of the processes involved in this practice grew. Following the heightened awareness regarding the imposed threat of MTM to the environment, issues regarding the subsequent impacts on human health have arisen. Thus, creating a health impact assessment to aid in policy decision-making for MTM is a necessary step to increase awareness and decrease the risk of potential human health effects of this practice.

Scope

Mountaintop coal mining is a surface mining process involving the removal of mountaintops to expose coal seams and disposing the mining overburden in adjacent valleys. The resulting “valley fills” occur in steep terrain where there are limited disposal options. MTM is used widely across southern Appalachia and damages freshwater aquatic ecosystems and the surrounding environment by burying streams and headwaters. MTM operations are most abundant in southern West Virginia, western Virginia, eastern Kentucky, and a few areas of eastern Tennessee (EPA, 2010). This project will focus on MTM in West Virginia (WV) and the Appalachia region.

Mining operations are regulated under the Clean Water Act (CWA), which controls the discharge of pollutants into streams from valley fills (EPA, 2010). Coal mining processes are also controlled by the Surface Mining Control and Reclamation Act (SMCRA) of 1977 (EPA, 2010).

MTM is comprised of several different steps. First trees and vegetation, as well as layers of rock and topsoil above the coal, called overburden, are removed. Trees are usually leased to a
timber company to be logged and sold. The overburden should either be saved or spread over an existing stripped site. Next the area is prepared for pre-stripping using shovel loader and dump trucks and an area is pre-stripped to make a foundation for the dragline. The dragline is the most crucial piece of machinery for MTM because it digs and removes the coal. Access roads are constructed to reach the operation. The subsoil and rocks are drilled, blasted, and removed. Draglines excavate lower layers of coal with spoils placed in spoil piles. Re-grading begins as coal excavation continues. Overburden is either used in re-grading or placed into a valley fill. Once coal removal is complete, final re-grading takes place and the area is re-vegetated.

Over the last 40 years, there has been an increase in MTM. The energy crisis of 1970s created an increase in the widespread demand of MTM. Throughout the 1980s, forty-four permits were granted covering 9,800 acres in contrast to 2002 where permits covering 12,540 acres were granted in only 9 months. Also during the 1980s the introduction of the dragline excavator, which can be as tall as twenty stories high in MTM operations, allowed for the faster removal of coal. Also, MTM experienced further expansion in the 1990s when the government amended the Federal Clean Air Act to include a stricter emissions standard. This increased the demand for the low sulfur, high volatility coal in West Virginia. MTM is also a quicker, cheaper method of coal mining than other practices.

In the past, mining was a source of economic advantage. However, recently coal employment has been dramatically reduced due to increased mechanization of the mining industry. Communities that flourished in the past have turned into ghost towns with empty storefronts and few economic prospects. With the environmental destruction of MTM becoming increasingly evident in WV, government leaders are turning to other sources of economic growth. For instance, tourism has become one of the most promising new pathways for economic
development. Nonetheless, the coal industry will always have a major presence in WV due to the world’s relentless energy consumption.

In addition to the environmental and socioeconomic impacts of MTM, the health effects of MTM on the surrounding populations have yet to be addressed. Research regarding the health impacts of MTM is limited, but there have been several studies that suggest a link between coal mining and adverse health outcomes. For instance, one study linked higher risk of cardiovascular disease with air and water contamination consistent with toxicants found in the coal mining process (Hendryx & Zullig, 2009). Other studies have found relationships between cancer mortality in heavy coal mining areas as well as increased rates of kidney and respiratory diseases (Hitt & Hendryx, 2010). However, the direct relationship between adverse health outcomes and MTM has yet to be firmly established.

Although MTM produces a large proportion of coal necessary to fuel the nation’s energy demands, there are many adverse effects of MTM. The negative impacts of MTM include environmental devastation, socioeconomic effects on the surrounding communities, and jeopardizing human health. The environmental impacts of MTM have been established through collaboration of the U.S. Army Corps of Engineers (Corps), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Interior’s Office of Surface Mining (OSM) and Fish and Wildlife Service (FWS), and the West Virginia Department of Environmental Protection (WVDEP). The agencies conducted or funded over 30 environmental impacts studies of mountaintop mining and associated excess spoil disposal valley fills (VF). The findings of these studies were used by the organizations to develop a Final Programmatic Environmental Impact Statement (FPEIS) in order to reduce the adverse environmental impacts of MTM/VF operations.
The PEIS was created to “consider developing policies, guidance, and coordinated agency decision-making processes to minimize the adverse environmental effects to waters of the United States and to fish and wildlife resources affected by mountaintop mining operations, and to environmental resources that could be affected by the size and location of excess spoil-disposal sites in valley fills within the Appalachian study area in West Virginia, Kentucky, Virginia, and Tennessee” (EPA, 2005). After seven years of research and evaluation, the agencies finalized the PEIS. The summarized findings of the FPEIS indicated that “streams in watersheds where MTM/VF exist are characterized by an increase of minerals in the water as well as less diverse and more pollutant-tolerant macro invertebrates and fish species” (EPA, 2005). Studies for the FPEIS also found that between 1992 and 2002 approximately 1200 miles of headwater streams were directly impacted by MTM/VF features including coal removal areas, valley fills, roads, and ponds, and from 1985 to 2001 an estimated 724 stream miles were covered by valley fills (EPA, 2005). Overall, the FPEIS highlights many of the adverse environmental impacts of MTM, yet the extent of those impacts on human health is left unanswered.

Currently the EPA, OSM, Corps, FWS are conducting a Cumulative Impact Assessment (CIA) to collaboratively address all MTM impacts. One of their aims includes clarifying and strengthening the epidemiological evidence base for health impacts from MTM. The CIA is focusing their efforts on Boone County, part of the Coal River Watershed, because (1) there is extensive mining in this area, (2) data on water quality and aquatic biology are available, (3) the EPA conducted previous research on aquatic health effects in this area, and (4) there is preliminary evidence for a large EJ component. Therefore, most of the data collected for this HIA represents Boone County with some data reflecting the state of West Virginia as a whole.
Environmental Impacts of Mountaintop Mining

For a thorough analysis of the environmental impacts of MTM see the EPA FPEIS summary: http://www.epa.gov/region3/mtnstop/pdf/mtm-vf_fpeis_summary.pdf. A brief summary of the results from the studies of the FPEIS is provided below.

Aquatic Impacts

Key findings of the studies conducted for the Final Programmatic Environmental Impact Statement include:

- Concentrations of major chemical ions (Mn, Fe, Al) are persistently elevated downstream
- Degraded water quality reaches levels that are acutely lethal to standard laboratory test organisms
- Macro-invertebrates and fish are consistently and significantly degraded
- Selenium concentrations are elevated, reaching concentrations that have caused toxic effects in fish and birds
- Springs, and streams are permanently lost with the removal of the mountain and from burial under fill

Water Quality

1. Perched aquifer systems are removed by MTM, resulting in enforced formation of new aquifers (EPA, 2003). This may disrupt local well systems, as well as have a serious impact on streams in the region, some of which may be eliminated (EPA, 2003).
2. There may be some diversion or elimination of aquifer recharge waters due to MTM and valley fill systems – although little research has been done in this area to determine the full impacts (EPA, 2003).
4. Acidic discharges with high concentrations of iron and sulfate (> 2000 mg/l) can develop, and this can be very reactive with the overburden material, creating high total dissolved solid (TDS) concentrations in the groundwater (EPA, 2003).
5. High levels of sodium, magnesium, calcium and aluminum were found in coal mine drainage, and increased levels of selenium were found in bituminous basic discharge
water. Also, mineral concentrations in out flowing water may infiltrate aquifers and disrupt natural biochemical systems (EPA, 2003).

**Air Quality Impacts**

The Clean Air Act does not currently regulate air pollution from MTM because scientific evidence regarding levels of exposure and subsequent health impacts is insufficient. A recent study conducted through the collaboration of the Sierra Club and North Carolina State University to assess roadside dust in Roda Virginia where residents live within 50ft of heavily trucked roads (Aneja, 2009). These trucks carry uncovered loads of coal continuously throughout the day and night potentially creating harmful amounts of dust and PM$_{10}$ in the air.

The Air Pollution Control Board and the Virginia Department of Environmental Quality (VADEQ) requested that the ATSDR evaluate reported levels of PM$_{10}$ air pollution in Roda, VA and address corresponding public health concerns. The ATSDR reviewed three reports evaluating particulate matter and dust characterization in the Roda area and published a Letter Health Consultation report. The ATSDR concluded that exposure to particulate matter at the highest levels reported in 2008-2009 were likely to be of health concern, especially for sensitive individuals. Concentrations of PM$_{10}$ reached levels of up to 469 µg/m$^3$/24 hour period, well above the NAAQs standard of 150 µg/m$^3$/24 hours (Aneja, 2009). The ATSDR concluded that the air quality was of concern especially during the intermittent peak periods of dust caused by high production and dry conditions.

Exposure to PM$_{10}$ can cause irritation of the eyes, nose, throat, and lungs in healthy populations and wheezing, shortness of breath, bronchitis, increased asthma attacks, and aggravation of lung or heart conditions in sensitive populations. The study also concluded that exposure to metals in the air is not likely to be a public health concern. The study proposed three actions to reduce air pollution exposures in Roda: (1) conducting additional air quality
measurements and modeling studies; (2) meeting with residents of affected communities; and (3) requiring mining facilities that contribute to the dust problem, including those that cause coal and other materials to be hauled through Roda to implement reasonable precautions to control fugitive dust (Aneja, 2009). ATSDR recommendations included (1) federal, state, and local agencies in the area continue to take any available actions to reduce particulate matter and dust affecting the residential areas along Roda Road and other areas with similar conditions, and (2) sensitive individuals take personal health-protective steps to reduce their particulate matter exposures.

The ATSDR evaluation and corresponding recommendations from the Roda study of air quality can be applied to similar areas in Boone County where houses are also located adjacent to heavily trucked roads. The findings of environmental assessments provide evidence for potential health risks from MTM exposures. However, air pollution exposure from MTM and its subsequent health impacts on surrounding communities requires further investigation.

Analysis of Literature

A review of existing literature on the human health impacts of MTM was attempted to establish the baseline scientific understanding of MTM community health risks. Unfortunately, there are no completed studies on MTM and human health. Thus, the majority of research analyzed in this literature review evaluates the relationship between traditional coal mining, not MTM, and human health. Nonetheless, examining the available literature is valuable for understanding potentially relationships between exposure and disease, as well as designing future studies.
The region of Appalachia is generally characterized by social inequalities and health disparities (Hendryx, 2008). The inequalities and disparities experienced by communities due to coal mining have become a major focus of public health agencies such as the U.S. Environmental Protection Agency (EPA). Additionally, numerous environmental contaminants associated with coal extraction and processing are known to contribute to cardiovascular disease (CVD) including toxic metals such as arsenic and cadmium, particulate matter (PM) and polycyclic aromatic hydrocarbons (Hendryx & Zullig, 2009). All of these factors have influenced and warranted the scientific evaluation of coal mining on human health.

Coal mining areas are typically of lower socioeconomic status (SES) relative to non-mining areas, and coal mining states such as West Virginia have lower SES overall than the U.S. average (Hendryx, 2008). Additionally, lower SES has long been correlated with higher disease incidence, prevalence and poorer health outcomes across the spectrum of diseases particularly chronic conditions, such as diabetes, heart disease, and cancer and recent studies have suggested that in Appalachia environmental pollution from the mining industry is a contributing factor (Hendryx & Ahern, 2009). For example, Hendryx and Ahern (2009) found that age-adjusted mortality rates were higher every year from 1979 through 2005 in Appalachian coal mining areas than non-mining areas of Appalachia or the U.S. They also found that the highest mortality rates were associated with areas having the highest levels of mining activity (Hendryx & Ahern, 2009).

Another factor that may contribute to the higher mortality levels is elevated stress caused by economic disadvantage and environmental degradation. Adjusted mortality rates were found for both males and females eliminating occupational exposure as the key explanatory factor (Hendryx and Ahern, 2009). Low socioeconomic status was found to be a significant factor in
morbidity and premature mortality, and the higher unemployment and poverty rates in coal mining regions of Appalachia is likely a contributing factor to the region’s poor health (Hendryx and Ahern, 2009). The heaviest coal mining areas of Appalachia had the poorest socioeconomic conditions (Hendryx and Ahern, 2009).

Before adjusting for covariates, the number of excess annual age-adjusted deaths in coal mining areas ranged from 3,975 to 10,923, depending on years studied and comparison group (Hendryx & Ahern, 2009). Areas with heavy mining have the highest unemployment rates in the region and coal mining counties in West Virginia experienced a mean net loss of 639 people to out migration between 1995 and 2000, compared with a mean net migration gain of 422 people in non-mining counties (Hendryx and Ahern, 2009).

Among West Virginia adults, residence in counties with mining operations was associated with poorer health status and higher risk for cardiopulmonary disease, chronic lung disease, hypertension, and kidney disease, after controlling for covariates (Hendryx & Ahern, 2008). This study evaluated self-reported health indicators that were not confirmed by medical records and had a very low participation rate. However, it still suggests directions for further research.

Hendryx and Zullig (2009) conducted a study in to compare CVD rates for men and women residents of Appalachian coal mining counties before and after controlling for covariates. The CVD was self-reported in this study and not confirmed by medical records. Also, the participants are a survivor population and may not necessarily represent the exposure and covariate experience of those who did not survive CVD. This study used national Behavioral Risk Factor Surveillance System (BRFSS) data to assess CVD risk in coal mining areas and incorporated important CVD covariates such as alcohol consumption, diabetes, obesity, and smoking. The results were that people in mining areas have higher risk of cardiovascular disease
(CVD) (OR=1.22, 95% CI 1.14-1.30), angina or coronary heart disease (CHD) (OR=1.29, 95% CI=1.19-1.39), and heart attack (MI) (OR=1.19, 95% CI = 1.10-1.30) after adjusting for smoking, alcohol, gender, education, race, income, physician supply, and metropolitan status (Hendryx & Zullig, 2009).

Hendryx (2009) related county-level, age-adjusted mortality rates for the years 2000–2004 for heart, respiratory and kidney disease to tons of coal mined and found that total chronic heart, respiratory, and kidney disease, and kidney disease mortality rates were significantly higher in coal mining areas of Appalachia than non-coal mining areas for males and females. The study used Poisson regression models and included covariates of percent male population, college and high school education rates, poverty rates, race/ethnicity rates, primary care physician supply, rural-urban status, and smoking rates.

Cancer mortality is high relative to the U.S. in West Virginia and parts of Appalachia and has been linked with behavioral risk factors, such as smoking, associated with poor socioeconomic conditions (Hendryx, Fedorko, & Anesetti-Rothermel, 2010). Here again, coal mining activities potentially contribute to the elevated cancer rates. As noted by Hendryx (2008) and Hendryx and Ahern (2009) persons living in coal mining counties of Appalachia have elevated rates of total mortality and lung cancer mortality, after controlling for socio-economic status, availability of health care and other behaviors. Mining processes have contaminated trillions of gallons of water and released tons of particulate matter into the air in mining communities and it is known that coal contains many established carcinogens such as arsenic, cadmium, chromium, nickel, and beryllium (Hendryx, Fedorko, & Anesetti-Rothermel, 2010). Distance-weighted, at-risk population coal mining exposure measure was significantly correlated to cancer mortality in WV for total cancer and 3 subgroups after controlling for smoking rates.
and this held for all components of mining processes (injection, preparation plants, impoundments, and mining sites) (Hendryx, Fedorko, & Anesetti-Rothermel, 2010).

Although the investigators of this study used distance weighting, they aggregated this data to the county level and combined these processes into a single index for the regression analyses. This reduced the values of distance weighting and removed the opportunity to evaluate each mining process separately in the regression analyses. Also, they use OLS instead of a weighted or Poisson regression method. Nonetheless, the study is still warrants further research.

As noted previously incidence and mortality of cancer and other diseases in Appalachia is generally thought to result from higher smoking rates and associated low socioeconomic conditions and behaviors. Elevated arsenic levels in drinking water sources in coal mining areas have been found in areas of central Appalachia. Elevated lung cancer mortality rates largely attributed to smoking and socioeconomic factors may also be caused by exposure to environmental contaminants associated with mining processes. Hendryx, O'Donnell & Horn (2008) investigated whether elevated lung cancer mortality in Appalachia is attributable to strictly smoking and socioeconomic factors or whether an additional effect associated with proximity to heavy coal-mining areas is a contributor.

The Hendryx, O'Donnell & Horn (2008) study found that lung cancer mortality is higher in heavy coal-mining areas, followed by all other areas of Appalachia and the nation (p<.001) after accounting for covariates of gender, education, poverty, race, urban status, smoking, southern states, and Appalachian country. Additional studies have found that volume of coal mining is significantly related to hospitalization risk for hypertension (odds increased 1% for each 1462 tons of coal) and chronic obstructive pulmonary disease (odds increased 1% for each
1873 tons of coal) controlled for age, gender, insurance, co-morbidities, county poverty, county and social capital (Hendryx, Ahern & Nurkiewicz, 2007).

Another study found that residence in counties with mining operations increases the odds of low birth weight. Specifically, in mining areas odds of low birth weight are increased by 14 to 16% depending on the amount of mining as compared to areas with no coal mining (Ahern, Mullett, MacKay, & Hamilton, 2010). There was no confounding by maternal risk factors such as smoking, education, prenatal care, or age in this study. A final study showed that ecological integrity was inversely related to age-adjusted cancer mortality rates (total p<.01; digestive, breast, and respiratory p<.01; urinary p<.05), controlled for poverty, access to health care providers, urbanization, education, smoking and that mining was significantly related to total cancer mortality (Hitt & Hendryx, 2010).

These studies provide weak evidence for a causal link between MTM and elevated rates of adverse health effects. Many of the studies reviewed were ecological, utilized crude ecological exposure variables, and were conducted using secondary data. They do not provide direct assessments of environmental air and water quality in mining areas in relation to individual exposures and health outcomes. Still, the results warrant further research using rigorous epidemiological methods. In order to take into account the variability in disease rates across counties, due to difference in population size, researchers should use a weighted regression approach or Poisson regression. They would also need to check for over dispersion in those analyses that could be due to disease rate correlations among adjacent counties.

Additionally, more comprehensive research, including environmental chemical analyses and biomonitoring, would require significantly greater funding. Yet, given the long latency periods associated with most of the diseases of interest, conducting dispersion modeling and
historical exposure reconstruction rather than biomonitoring may be more appropriate. If priority lies with removing current exposure sources, then biomonitoring may be necessary. However, the results of these associational studies are sufficient to identify significant correlations between MTM activity and a variety of health disparities. Study findings indicate that health disparities are elevated in Appalachian coal mining regions for a number of common diseases including cardiovascular disease (CVD) and lung cancer. Risks for these diseases are affected by many factors including lifestyles, health-related behaviors and the cultural influences, genetic predispositions, environmental exposures, and lower socioeconomic status (SES).

The existing body of literature suggests that various negative health outcomes are not the result of a single exposure, but may reflect chronic exposures to multiple environmental pollutants, both air and/or water, which will vary for each individual. Future research on MTM faces the challenge of addressing the many confounders that are involved in assessing health effects and strength of associations to MTM. However, it is rare for a significant confounding to occur in a study because the covariate must be a strong risk factor for the disease of interest and have at least a moderate association with the exposure of interest. Even for smoking-related diseases, smoking will not be a confounder unless it has at least a moderate association with MTM exposure. So it is very likely that there will not be many confounders that will have a significant impact on a MTM exposure-disease relationship at the individual level. On the other hand, exposure misclassification is likely to be an important bias.

Given the high level of concern about overall environmental and human health effects from mountain top mining (MTM) and the increasing focus of federal agency decisions to review and either approve or disapprove mining permits, the existing literature base is inadequate. Rigorous primary research needs to be conducted in order to develop the level of relative
certainty decision makers will need to disapprove permits or require pollution reduction measures to protect health.

**Health Characterization of Boone County**

The state of West Virginia has a large population of residents living in rural areas. According to the West Virginia Health Care Authority 20 of West Virginia’s 55 counties are defined as 100% rural, and an additional 14 defined as 75% rural. The communities are small and isolated limiting distribution and access to health care information and services. Thus, understanding the distribution and rates of disease is important to address disproportionate health impacts they may face from MTM operations.

The EPA and CDC attempted to collect detailed data for cancer, asthma, blood lead levels, but they were only available at county level. Due to the scale of available data there was limited opportunity to contribute to the existing body of literature and further refine those analyses.

Elevated blood lead levels (BLLs) were rare in the children of Boone County. There were zero confirmed cases out of 210 children tested in 2008 (CDC, 2008). Boone County appears to have a relatively good testing rate compared to other WV counties and is in the lowest category of % of children with elevated blood lead levels compared to other WV counties (CDC, 2008). However, the testing rate of 11.4% can be improved. In 2007, there was one confirmed case of elevated BLLs in Boone County out of 189 children tested (0.53% confirmed elevated) (CDC, 2008). The state of West Virginia had 94 confirmed cases of elevated BLL in children in 2008 (CDC, 2008).
For a complete list of WV county BLLs visit this website:


Table I. CDC Blood lead levels for children in Boone County West Virginia

<table>
<thead>
<tr>
<th>Year</th>
<th>County Name</th>
<th># of Children Tested</th>
<th>Percent of Children Tested</th>
<th>Total # of Confirmed Cases</th>
<th>Percent of Children With Elevated Blood Lead Levels</th>
<th># of Addresses-Multiple Children w/Confirmed EBLLs *</th>
<th>Census 2000 Data</th>
<th>% of Children &lt; 6 Under Poverty</th>
<th>Estimated Population of Children &lt; 6, 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Boone County</td>
<td>210</td>
<td>11.4%</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
<td>11,575</td>
<td>2,760</td>
<td>31.0%</td>
</tr>
<tr>
<td>2007</td>
<td>Boone County</td>
<td>189</td>
<td>10.0%</td>
<td>1</td>
<td>0.53%</td>
<td>0</td>
<td>11,575</td>
<td>2,760</td>
<td>31.0%</td>
</tr>
</tbody>
</table>

Cancer data was only available at the county level and after consultation with Dr. Ed Gracely, Assistant Professor of Biostatistics at Drexel University, it was determined that it would not be of value if further analyzed. Lung cancer incidence rates in Boone County were elevated above state levels (Appendix H), which could be attributed to a very high percent of the population who smoke cigarettes. The average age-adjusted incidence rates of cancer in several West Virginia Counties compared to state rates are located in Appendix I.

Asthma data was also available at the county level (Appendix F). Adult asthma levels were elevated in Boone County (9.0-11.8%) and are above the national average of 7.7% (CDC, 2009). A graph of pediatric asthma hospitalization rates by county is located in Appendix G. According to the National Survey of Children’s Health (NSCH), 11.1% WV children under the age of 18 had asthma in 2003, compared with 8.9% of children in the US (NSCH, 2003).

Particulate matter, which is a primary pollutant from MTM, is associated with asthma exacerbation. Many scientific studies have linked particulate matter, especially fine particles (alone or in combination with other air pollutants), with a series of significant health problems,
including: premature death, respiratory related hospital admissions and emergency room visits, and aggravated asthma (EPA, 1997). The relationship between elevated asthma rates and air pollution from MTM requires further investigation. Asthma has not been studied in any of the current scientific literature available for mining.

In contrast to the limited scientific evidence of a relationship between MTM and human health risks, the Environmental Justice component of MTM has been confirmed through the collection of Census data and visits to mining communities.

**Environmental Justice**

Executive Order 12898 states, “each Federal agency shall make achieving environmental justice (EJ) part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States” (Federal Register, 1994). In the context of MTM, EJ is a very pertinent topic. MTM has a significant EJ impact because many of the communities surrounding mining sites have high poverty rates, low per capita income, and other economic disadvantages.

Often, mining communities often do not have municipal water sources, sewage treatment facilities, and trash and recycling collection. They also have poor educational attainment compared to the rest of the U.S. population and higher poverty rates. In addition to these disadvantages, these communities are further impacted by the invasion of MTM. They must deal with large trucks hauling uncovered loads of coal constantly throughout the day on two lane roads over single lane bridges. Mountainsides are littered with metal railings and tracks that
transport coal and coal slurry to and from mining sites. There are also intermittent explosions throughout the day and night, and of course, entire mountains are defaced.

According to government regulations, mining companies are required to have public meetings to hear concerns and issues the community may have in regards to new or expanding mining projects. However, these meetings can often be bombarded with mining employees shipped there to outnumber people who may oppose new mining projects. This inhibits the ability of others in the community to voice their concerns and discourages their motivation to oppose MTM. Similarly, mining companies are also required to share their mining footprint plan with the community for input and comment. Often only the first draft of these plans is provided to the communities for review. This means the community’s input is not relevant by the time the mining footprint plan is finalized. Thus, MTM is inherently infringing on the environmental justice rights of these West Virginia populations.

In accordance with the Cumulative Impact Assessment of several government agencies, data on the demographic characteristics of the Boone County population was collected and evaluated for EJ issues.

**Environmental Justice Evaluation of Boone County, West Virginia**

Characteristics of Boone County, West Virginia were collected from the 2000 Census. The data do not reflect population and housing characteristic changes captured in the 2010 Census, which currently has limited availability. The following are test case ZIP codes in Boone County: 25028 (Bob White, WV), 25093 (Gordon, WV), 25130 (Madison, WV), 25140 (Naoma, WV), 25181 (Seth, WV), 25193 (Sylvestre, WV), and 25204 (Twilight, WV). In these areas there is a predominance of rural living. Table 1 demonstrates some degree of variability between
the seven test case ZIP codes in the West Fork of Pond Fork in the Coal Watershed, Boone County, WV for population size, number of housing units, and the inclusion of one that is classified approximately 40 percent urban relative to the remaining six, which are 100 percent rural. Table 2 reflects the same predominance of housing units in rural communities. Rural living in itself does not imply adversity. However, combined with other relevant socioeconomic and demographic factors it provides a picture of a community with the potential for health consequences from environmental injustice.

2000 Census counts and estimates are not available for 25093 (Gordon, WV). The current population is estimated at 109 people, while in 2000, it was zero. Currently, there are eight streets with 31 properties listed online, indicating that in-migration of residents has occurred since 2000. Although this is still a very sparsely populated area and the influx could be attributed to failure to collect Census data in the past.

The ZIP code, 25130 (Madison, WV) is the only ZIP code with urban populations and urban housing units. Relative to the remaining six ZIP codes, data from this ZIP code has the potential to influence statistical results of the remaining rural ZIP codes due to its population size and urban density. This area could likely to be the center of access to health care for all selected ZIP codes unless there is another region supplying health care.

The test case population is approximately 10 percent more urban than the population in Boone County as a whole, which could be attributed to the Madison zip code. The U.S. and State of West Virginia populations are 79 and 46 percent urban, respectively (Table 1). The predominance of rural living is also reflected in the housing characteristics (Table 2), for the test case area, the county, and the state, relative to the U.S. The proportion of housing units with utility gas or electrical service as a source of heating fuel in the test case area (11%) potentially
indicates the population as a whole is less isolated than the rest of Boone County; although, this likely reflects the influence of the single more urban ZIP code, 25130, in the Madison community (Table 4). In the rural Naoma community in ZIP code 25140, in particular, 39 percent of its housing units are not hooked up to either utility gas or electricity as a source of heating fuel, and five percent lack complete plumbing. This community is the third most populous of the seven ZIP codes (Table 1).

In terms of poverty, the population in the test case area and in the rest of Boone County is living in deeper poverty (21-22%) in contrast to the rest of the State of West Virginia (18%) and the U.S (12%) (Table 3). When examined by ZIP code, the influence of the more urban Madison community in ZIP code 25130 is removed from the overall poverty rates among the test case ZIP codes. Poverty rates exceeding 30 percent are noted in the Bob White and Twilight communities, ZIP codes 25028 and 25204. They exceed 24 percent in the Seth and Sylvester communities, ZIP codes 25181 and 25193. This variation in poverty rates is important to note, as the Seth community is the second most populous ZIP code in the test case area (Table 1). Compared to the U.S. WV had a 4.2% higher poverty level than the U.S. in 2008 (U.S. Census Bureau, 2010).

According to the 2000 Census Report, the median age in West Virginia is 38.9, compared to 35.3 for the U.S. In WV, the proportion of the population 65 years and older is 15 percent with Boone county at 14 percent and 12.4 percent across the nation (Table 3). In the Boone county zip-codes of 25193 and 25204 the percent aged 65 years and older is 18-19 percent. The gender distribution and average household size are consistent across all geographic regions (Table 4). This information gives insight into the amount of individuals who are old enough to work and the age distribution throughout the state and county. It also represents a outmigration of young adults from the area. A disproportionate amount of people older than 65 could also pose a burden
on the rest of the population in certain areas of West Virginia due to health care costs and inability to contribute to the work force.

The median per capita income in 2010 for WV was $32,641 and the median household income in 2008 was $37,528. These figures are both below the U.S. per capita and median income of $40,584 (2010) and $52,029 (2008) respectively (U.S. Census Bureau, 2010). Boone County’s median household income in 2008 was $32,794 and per capita income in 2002 was $19,705 (U.S. Census Bureau, 2010). This represents lower socioeconomic status in West Virginia and Boone County areas compared to the rest of the United States.

According to the 2009 Census report, the majority of the WV population is white (94.4%) compared to 79.6% in the U.S. Boone County is predominantly white (98.1%). Based on this data, there is not a disproportionate impact of MTM on minority populations in WV.

Table II. Minority populations WV and U.S. (U.S. Census Bureau, 2010)

<table>
<thead>
<tr>
<th>Minority Population</th>
<th>WV</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>White persons, percent, 2009 (a)</td>
<td>94.4%</td>
<td>79.6%</td>
</tr>
<tr>
<td>Black persons, percent, 2009 (a)</td>
<td>3.7%</td>
<td>12.9%</td>
</tr>
<tr>
<td>American Indian and Alaska Native persons, percent, 2009 (a)</td>
<td>0.2%</td>
<td>1.0%</td>
</tr>
</tbody>
</table>

The proportion of disabilities among the Boone county population of those aged 5 years and older is similar to the national level (Table 6). The proportion of the population reporting a sensory disability is 19 percent; a physical disability, 41-43 percent; a mental disability, 25 percent; and limitations in self-care, 14 percent, respectively (Table 6). The types of disabilities are described in Table 6. Table 6 does not show additional employment disabilities and going outside the home disabilities ascertained among adult populations in the 2000 Census.
Overall, West Virginia has adequate access to health care and health insurance as compared to the general population as demonstrated by 2008-2009 Kaiser Family Foundation (KFF) statistics. About 20 percent of West Virginia’s total population is enrolled in Medicare with 47% of people carrying employer-based health insurance (KFF, 2010). Only 2 % of the West Virginia population has individual health insurance plans, 3% lower than the rest of the U.S. population (KFF, 2010). West Virginia’s rate of uninsured individuals is 15%, 2% lower than the national average (KFF, 2010). Both the U.S. and West Virginia have 16% of their populations with Medicaid coverage (KFF, 2010). West Virginia has a 6% rate of children who are uninsured, 4 % lower than the U.S. rate (KFF, 2010). West Virginia has a childhood obesity rate of 35.5%, slightly above the U.S. rate of 31.6% (KFF, 2010).

In 2006, the infant mortality rate in West Virginia is 7.6%, slightly higher than the U.S. rate of 6.8% [Child and Adolescent Health Measurement Initiative (CAHMI), 2007]. In West Virginia, 69% of children are immunized, which is slightly below the national average of 72% (CAHMI, 2007). The percentage of mothers who seek prenatal care in their first trimester was 82.8% almost the same rate in the U.S. population 83.2% (CAHMI, 2007). Also, 74.4% of children in West Virginia have access to medical and dental care compared to 72% of the general population (CAHMI, 2007).

The statistics of health care access for residents of West Virginia may not accurately describe health care availability for rural populations. West Virginians who live in rural areas may qualify for government subsidized health insurance but may not have means of transportation to medical facilities. This can be attributed to deficient public transportation and individuals lacking the financial means to purchase a car. Also, the number of dental and medical clinics in these rural areas
According to the CDC in 2009, 25.6% of West Virginians were smokers compared to 18.3% of the U.S. population. WV is tied with Kentucky for having the highest rate of cigarette smoking in the country (CDC, 2009). Smoking is a serious confounder in epidemiologic studies making the high rate of smokers in WV a limitation to conducting MTM health research.

In March 2011, the unemployment rate in West Virginia was 9.7%, higher than the national average of 9.2% (Appendix D). Boone County’s unemployment rate was 8.2% in 2011, lower than both WV and the U.S. (U.S. Dept of Labor, 2010). The unemployment rate for WV shows that the state is struggling to employ its residents. The reason for this is unclear and cannot be confidently attributed to MTM. Boone County, an area with large amounts of MTM, has the lowest unemployment rate of the three regions.

It has been proposed that mining companies choose to center their operations in poverty stricken, economically disadvantaged areas such as Boone County. Companies do this because these areas offer less competition with other industries, less enforcement of regulations, and dependent employees. Appendix B shows a graph of the mining footprint surrounding Boone County. Additionally, communities surrounded by mountaintop mining often do not have a strong political voice because they are hampered by the lack of education attainment and the political influence of the mining industry itself. The low population density, see Appendix C, of Boone County and many other parts of WV also limit the strength of communities to oppose MTM operations. The mining industry wields major political clout in Washington by making hefty campaign contributions to GOP lawmakers and with expensive lobbying efforts aimed at blunting the impact of environmental/safety-related legislation. Since 2005, mining firms and their employees donated more than $13 million to federal lawmakers, 74% of that money went to GOP candidates.
Mining companies use their financial power to influence government officials and policy decisions to favor less strict regulations and to win legal battles. For instance, in 2004, Massey Energy chairman contributed $3 million to the campaign of a West Virginia judicial candidate, who later played a pivotal role in overturning a $50 million judgment against Massey Energy. The citizens of Appalachia cannot compete with the financial power of the mining industry in order to protect themselves from potential health threats of MTM.

**Tables of Demographic Characteristics of Boone County WV by Zip codes**

### TABLE 1: Nation West Virginia Boone County 2000 Census Population Characteristics by ZIP Codes (Community Name)

<table>
<thead>
<tr>
<th></th>
<th>Nation</th>
<th>West Virginia</th>
<th>Boone County</th>
<th>All ZIP Codes</th>
<th>25028 (Bob White)</th>
<th>25093 (Gordon)</th>
<th>25130 (Madison)</th>
<th>25140 (Naoma)</th>
<th>25181 (Seth)</th>
<th>25193 (Sylvester)</th>
<th>25204 (Twilight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
<td>281M</td>
<td>1.8M</td>
<td>25,535</td>
<td>11,144</td>
<td>262</td>
<td>NA</td>
<td>5,620</td>
<td>1,723</td>
<td>2,581</td>
<td>618</td>
<td>340</td>
</tr>
<tr>
<td>% Popn Rural</td>
<td>21.0</td>
<td>53.9</td>
<td>87.9</td>
<td>78.7</td>
<td>100.0</td>
<td>NA</td>
<td>57.8</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### TABLE 2: Nation West Virginia Boone County 2000 Census Housing Characteristics by ZIP Codes (Community Name)

<table>
<thead>
<tr>
<th></th>
<th>Nation</th>
<th>West Virginia</th>
<th>Boone County</th>
<th>All ZIP Codes</th>
<th>25028 (Bob White)</th>
<th>25093 (Gordon)</th>
<th>25130 (Madison)</th>
<th>25140 (Naoma)</th>
<th>25181 (Seth)</th>
<th>25193 (Sylvester)</th>
<th>25204 (Twilight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Housing Units</td>
<td>116M</td>
<td>845K</td>
<td>11,575</td>
<td>5,140</td>
<td>119</td>
<td>NA</td>
<td>2,617</td>
<td>770</td>
<td>1,155</td>
<td>309</td>
<td>170</td>
</tr>
<tr>
<td>% HU Rural</td>
<td>22.4</td>
<td>53.6</td>
<td>86.5</td>
<td>77.0</td>
<td>100.0</td>
<td>NA</td>
<td>54.8</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>% HU Without Complete Plumbing</td>
<td>1.2</td>
<td>3.0</td>
<td>2.2</td>
<td>1.6</td>
<td>0.0</td>
<td>NA</td>
<td>1.03</td>
<td>5.4</td>
<td>0.9</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>% HU Not on Utility Gas or Electricity for Heat</td>
<td>18.4</td>
<td>20.1</td>
<td>7.4</td>
<td>11.1</td>
<td>19.8</td>
<td>NA</td>
<td>2.6</td>
<td>39.0</td>
<td>13.2</td>
<td>5.2</td>
<td>12.6</td>
</tr>
</tbody>
</table>

### TABLE 3: Nation West Virginia Boone County 2000 Census Population Determinations by ZIP Codes (Community Name)

<table>
<thead>
<tr>
<th></th>
<th>Nation</th>
<th>West Virginia</th>
<th>Boone County</th>
<th>All ZIP Codes</th>
<th>25028 (Bob White)</th>
<th>25093 (Gordon)</th>
<th>25130 (Madison)</th>
<th>25140 (Naoma)</th>
<th>25181 (Seth)</th>
<th>25193 (Sylvester)</th>
<th>25204 (Twilight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Population in Poverty</td>
<td>12.4</td>
<td>17.9</td>
<td>22.0</td>
<td>20.7</td>
<td>34.4</td>
<td>NA</td>
<td>17.4</td>
<td>19.8</td>
<td>24.6</td>
<td>24.7</td>
<td>33.1</td>
</tr>
<tr>
<td>% Population 65+</td>
<td>12.4</td>
<td>15.3</td>
<td>13.6</td>
<td>13.9</td>
<td>9.9</td>
<td>NA</td>
<td>13.7</td>
<td>14.6</td>
<td>12.7</td>
<td>17.5</td>
<td>19.4</td>
</tr>
<tr>
<td>% Population ≤6</td>
<td>9.6</td>
<td>8.0</td>
<td>8.7</td>
<td>8.4</td>
<td>7.6</td>
<td>NA</td>
<td>8.9</td>
<td>7.4</td>
<td>8.5</td>
<td>7.0</td>
<td>8.5</td>
</tr>
</tbody>
</table>
TABLE 4: Population % Population by Race % Popn by Hisp % Male Households Ave HH Size

<table>
<thead>
<tr>
<th>Population</th>
<th>White</th>
<th>Black</th>
<th>Other</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nation</td>
<td>75.1</td>
<td>12.3</td>
<td>12.6</td>
<td>12.5</td>
<td>49.1</td>
<td>105M</td>
</tr>
<tr>
<td>West Virginia</td>
<td>95.0</td>
<td>3.2</td>
<td>1.8</td>
<td>0.7</td>
<td>48.6</td>
<td>736K</td>
</tr>
<tr>
<td>Boone County</td>
<td>98.5</td>
<td>0.6</td>
<td>0.9</td>
<td>0.4</td>
<td>48.8</td>
<td>10,291</td>
</tr>
<tr>
<td>ZIP Codes</td>
<td>98.0</td>
<td>1.2</td>
<td>0.8</td>
<td>0.5</td>
<td>48.6</td>
<td>1,045</td>
</tr>
</tbody>
</table>

TABLE 5: % Population 25+ yrs by Educational Attainment

<table>
<thead>
<tr>
<th>Total Popn 25+ yrs</th>
<th>8th Grade or Less</th>
<th>Some HS, No Degree</th>
<th>HS or GED</th>
<th>Some College or Assoc Degree</th>
<th>College Degree and Higher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nation</td>
<td>182M</td>
<td>7.6</td>
<td>12.0</td>
<td>28.6</td>
<td>27.4</td>
</tr>
<tr>
<td>West Virginia</td>
<td>1.2M</td>
<td>10.0</td>
<td>14.8</td>
<td>39.4</td>
<td>21.0</td>
</tr>
<tr>
<td>Boone County</td>
<td>17,324</td>
<td>15.0</td>
<td>21.0</td>
<td>41.1</td>
<td>15.8</td>
</tr>
<tr>
<td>ZIP Codes</td>
<td>7,672</td>
<td>14.7</td>
<td>19.9</td>
<td>40.2</td>
<td>16.3</td>
</tr>
</tbody>
</table>

TABLE 6: Disabilities Among 5+ yrs Civ Noninst Popn

<table>
<thead>
<tr>
<th>Total No. Disabilities Reported</th>
<th>% Sensory</th>
<th>% Physical</th>
<th>% Mental</th>
<th>% Self Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nation</td>
<td>49.6M</td>
<td>18.7</td>
<td>42.6</td>
<td>25.0</td>
</tr>
<tr>
<td>West Virginia</td>
<td>523,735</td>
<td>18.6</td>
<td>43.4</td>
<td>24.8</td>
</tr>
<tr>
<td>Boone County</td>
<td>10,358</td>
<td>19.8</td>
<td>41.3</td>
<td>25.5</td>
</tr>
<tr>
<td>ZIP Codes</td>
<td>6,944</td>
<td>19.1</td>
<td>40.8</td>
<td>26.1</td>
</tr>
</tbody>
</table>

Note: People age 5 years old and over are considered to have a disability if they report one or more of the following criteria from one or more of the following categories as defined by the 2000 U.S. Census:

(a) sensory disability: blindness, deafness, or severe vision or hearing impairment;
(b) physical disability: substantial limitation in the ability to perform basic physical activities, such as walking, climbing stairs, reaching, lifting, or carrying;
(c) mental disability: difficulty learning, remembering, or concentrating;
(d) self-care disability: difficulty dressing, bathing, or getting around inside the home.

Additional disabilities apply to persons 16+ that are not reflected here.

(U.S. EPA, 2011)

Spruce No.1 Mine EPA Permit Veto

In 2007, the Corps issued a permit for the Spruce No. 1 mine, the largest surface mining operations ever authorized in Appalachia (EPA, 2010). However, the operation was delayed by litigation and operated on a limited scale until the EPA vetoed the permit for the Spruce No.1 in 2010. The veto determination was based on the EPA’s conclusion that the project could result in unacceptable adverse impacts to wildlife and fishery resources (EPA, 2010). Waste disposal for the mine would have buried over seven miles of streams, directly impacted 2,278 acres of
forestland, and degraded water quality in streams adjacent to the mine (EPA, 2010). This decision represented a ground breaking event in the regulatory atmosphere of MTM because it was the 13th 404(c) action in EPA history, the first post-permit 404(c) action, the first 404(c) protecting headwater stream ecosystems, and the first veto addressing surface coal mining (EPA, 2010).

**Spruce Mine No. 1 Determination of Impacts on Environmental Justice**

The EPA’s Environmental Justice decision-making framework regarding the Spruce No. 1 mine in Logan County West Virginia can be applied to Boone County because they have similar demographic and socioeconomic profiles. For instance, according to the 2000 United States Census, Spruce No. 1 is located in a census block group containing 335 people. Spruce No. 1 is located in a census block group where the average per capita income is $15,411 (U.S. Census Bureau, 2000). This is over $6,000 less than the national average of $21,587 and over $1,000 less than the West Virginia state average of $16,477 (Census, 2000). Moreover, 24% of the residents of Logan County live below the poverty line, which also exceeds state and national averages (Census, 2000). These characteristics are closely representative of corresponding Boone County statistics.

Due to the SES status of Logan County, EJ was taken to account in the Spruce No. 1 Environmental Impact Statement (EIS). However, EPA Region III remained concerned that the potential for disproportionately high and adverse effects on this population was not fully considered and addressed (EPA, 2010). EPA’s environmental justice analysis indicated that there might have been a disproportionately high and adverse impact on the low-income population affected by the mining activity. Additionally, EPA was concerned that the local community did not have the necessary information, or the opportunity, to meaningfully participate in the EIS
process. Specifically, EPA was concerned that the community was not informed when changes were made to different aspects of the mine project during the permitting and EIS process and therefore was not able to meaningfully comment on the final aspects of the mine.

Consideration should have included a characterization of the status of residents near the site and the conditions they face including any effects relating to the proximity of the blasting zone, locations of discharges of fill material, truck traffic, noise, fugitive dust, and habitat loss (EPA, 2010). Information concerning sources of drinking water for the effected populations (including municipal water supplies and private sources of drinking water including streams and/or wells) also should have been considered (EPA, 2010).

The EPA determined that the cultural implications of MTM were also not sufficiently considered. Many residents view the mountains affected by Spruce No. 1 as a cultural resource. In many cases the mountains have helped define their society and influence their daily lives. For example, the mountain ridges of southern West Virginia have for over two centuries been viewed largely as a “commons,” where local residents have foraged for wild medicinal herbs such as American Ginseng and Goldenseal (EPA, 2010). In many cases, collection of these wild herbs provides much needed supplemental income to local communities during times of unemployment or economic hardship (EPA, 2010). Removing these mountains may have profound cultural changes on the residents in the area, which must be considered in EJ determinations (EPA, 2010).

In order to satisfy Executive Order 12898, the EPA considered whether there were going to be “disproportionately high and adverse human health or environmental effects” from its regulatory action (EPA, 2010). In the context of a Clean Water Act Section 404(c) action, EPA is authorized to prohibit, restrict, or deny specification (or withdraw specification) of the discharge
of dredged or fill material at defined sites in waters of the United States whenever it determines that use of such sites for disposal would have an unacceptable adverse impact on “municipal water supplies, shellfish beds, fishery areas (including spawning and breeding areas), wildlife, or recreational areas” (EPA, 2010). Accordingly, EPA had considered its environmental justice analysis in the context of what impact Recommended Determination will have on 404(c) resources of the project site. EPA concluded that Recommended Determination under 404(c) will not have a disproportionately high and adverse human health or environmental effect on the low-income and minority populations of the project area, which neither prohibits nor authorizes coal mining (EPA, 2010).

Boone County has similar demographic and environmental justice risk factors as Logan County. The EPA determined that EJ was not violated for the Spruce mine as long as the mining companies upheld regulatory statutes. However, without data on water quality in private drinking wells, air pollution, and subsequent human health effects, developing recommendations to address EJ remains a challenge.

**Risk Analysis Matrix**

The risk analysis matrix is an attempt to stratify the existing knowledge base and associated claims by level of scientific certainty of the pollutant-health association. It evaluates the significance of identified health impacts with information from literature review, stakeholder consultation, knowledge of project context and developments, and experiences of previous HIAs in similar setting. The preliminary matrix is located in Appendix E.

**Personal Visit to West Virginia**

With the help of my preceptor Richard Paiste (EPA) and Robert Helverson (ATSDR), I visited communities in West Virginia surrounded by coal mining and natural gas extraction sites. The site visits included a trip to Prenter hollow and nearby areas which
were experiencing groundwater quality concerns. We also explored coal mining related activities that surround the area, including deep coal mining, coal slurry impoundment, coal slurry underground injection, and MTM sites. Finally, we went to Marsh Fork Elementary school which is located 400ft downhill from a 20 billion ton coal slurry impoundment, a coal dust complaint site, and the Bluestone Dam industrial areas along the rivers. I also attended the West Virginia Health Department’s annual planning meeting where they summarized projects from the past year and discussed goals and priorities for the upcoming year.

The objective of the trip was to observe the communities surrounding these sites and obtain a better understanding of the potential exposure scenarios in these areas. This trip allowed me to experience the significant impacts that mining and natural gas industries have on the neighboring communities. In addition to low socioeconomic status and decreased access to health care, they are faced with frequent explosions of dynamite throughout the day and night, large amounts of dust in the air, questionable water quality, ecological destruction, and heavy traffic from coal transport vehicles. This trip gave me greater insight of the disproportionate socioeconomic, environmental, and human health impacts that residents in this region are living with on a daily basis.

**Economic Costs and Benefits of Mountaintop Mining**

According to the National Mining Association (NMA), MTM operations provide lucrative wages that stimulate the economies of communities and regions surrounding these sites (2009). Average wages for miners is around $66,000 per year not including overtime, which is 57% above the average for other industrial jobs (NMA, 2009). Furthermore, in West Virginia, MTM accounts for 45% of coal production in the state (NAM, 2009). The NMA reports that there are approximately 14,000 surface coal miners in the Appalachia region (NMA, 2009). There are over 60,000 jobs created as a result of MTM operations when sales, related business,
and mining service staff members are included (NMA, 2009). Other economic benefits from mining include revenue from state and local taxes, which fund schools and education cultivation for the residents of West Virginia. Although, coal mining constitutes a large economic activity in some portions of Appalachia, it has also been linked to socioeconomic disadvantages in surrounding communities.

The economic disadvantages in Appalachia have been characterized by low employment in professional services, low economic diversification, and low educational attainment rates (Wood, 2005). Additionally, some argue that surface mining operations such as MTM do not create as many jobs in West Virginia as underground mining. Due to the mechanization of MTM and use of explosives, this process allows 2.5 times the extraction of coal per worker per hour as underground mining practice reducing the need for workers (NMA, 2007). According to studies by Hendryx and Ahern (2009), “areas with especially heavy mining have the highest unemployment rates in the region.” Thus, the economic benefits of MTM are evident, but it is not clear if they out weight the costs of MTM.

The U.S. Department of Energy (DOE) estimated in 1998 that 28.5 billion tons of high quality coal (i.e., high heating value, low sulfur content) remains in the Appalachian region. DOE reported about 280 million tons of coal were extracted by surface and underground mining from the area in 1998 (EPA, 2005). Coal produced from Appalachia continues to provide an important part of the energy needs of the nation. Almost all of the electricity generated in the region comes from coal-fired power plants. Although coal production remains high, productivity gains and new technology have reduced the need for coal miners. Unemployment, poverty, and out migration in the area are well above the national average.
However, coal mine operators purchase goods and services from other firms and spend wages on goods/services sold in the region creating a multiplier effect on regional economy. According to Marshall University Center for Business and Economic Research's (CBER), every direct job in coal mining in 1996 supported two other jobs in the state and every dollar’s worth of coal production supported an additional 52 cents in sales in other sectors of state economy (Burton, Hicks, and Kent, 2000). Additionally, in Boone County coal mining accounted for 1/3 of all employment in 1998 (EPA, 2005). In 1997 coal supported 5,032 direct and multiplier jobs, $308.3 million in wages, accounted for over half of all jobs, 2/3 of all wages, and over 4/5 of total value of the output for the county (EPA, 2005). The majority of mining in Boone County is underground mining and doesn’t completely reflect the impact of MTM on a community. However, these statistics demonstrate the tremendous impact mining has the economy in Appalachia.

An examination of mine employment statistics by researchers at Marshall University’s CBER points to the role of increasing productivity in the declines in West Virginia mining employment (Burton et al, 2000). The CBER study noted that coal production increased by 40% over the period 1980-1998 while underground employment declined by 70% and surface mining employment declined by 50% (Burton et al, 2000). The study also noted that average underground mining productivity in West Virginia increased from 2,100 tons per employee in 1980 to 8,000 tons per employee in 1998 (Burton et al, 2000). There are many factors that influence worker productivity and these statistics do not account for occupational injuries due to higher productivity or engineering/technological advancement in the coal mining process. Mining companies have adopted MTM because it relies on machinery, not man power, making it
a more efficient cost effective method of mining. Thus, the economic benefits of mining such as employment for residents are decreasing while the adverse impacts persist.

**Legal Framework for Mountaintop Mining**

The EPA is the federal agency that oversees MTM operations and determines when mine permits may be issued for new MTM projects. MTM is regulated under the authority of two federal statutes, SMCRA and the Clean Water Act (CWA). The CWA monitors the discharge of pollutants to streams from valley fills and the SMCRA monitors a broad range of environmental and other impacts of surface mining operations (EPA, 2011).

The CWA restricts the expulsion of all pollutants from any point source into the surrounding waters unless it complies with the permit issued to the mining operation (Copeland, 2011). There are two mining permit programs: the National Pollutant Discharge Elimination System (NPDES) program (CWA Section 402), controlled by the EPA and the dredge and fill permit program run by the US Army Corps of Engineers (CWA Section 404). Both permits are typically required for MTM and other surface coal mining initiatives. The dredge and fill permit is required for the discharge of mining overburden into U.S. waters and the NPDES permit allows “discharges from sediment ponds, on-site coal preparation facilities, and storm water discharges from the mine site” (Copeland, 2011).

The NPDES authority concentrates on wastewater discharges from industrial facilities and sewage treatment operations (Copeland, 2011). Section 402 permits include “limitations of the quantities, rates and concentrations of pollutants that reflect treatment with available pollution control technology and any more stringent limitations needed to meet state-established water quality standards for the receiving water” (Copeland, 2011). The EPA and Army Corps of
Engineers (Corps) have complementary roles in implementing the Section 404 permit program. The Corps issues permits for the discharge of dredged or fill material in accordance with EPA environmental guidelines (Copeland, 2011). The Section 404 permit aims to balance the favorable impacts of a proposed mining activity against the detrimental impacts reflecting national consideration for the protection and utilization of important resources (Copeland, 2011).

The U.S. Fish and Wildlife Service (FWS) also possess authority pertaining to MTM. The FWS implements and enforces the Endangered Species Act and the Fish and Wildlife Coordination Act (Copeland, 2011). The mining companies must consult the FWS to ensure that fish and wildlife conservation and impacts of threatened or endangered species are considered. Coordination with the FWS is required for SMCRA and CWA permit approval (Copeland, 2011).

The adverse impacts of MTM on the environment and surrounding communities have lead to legal criticism and challenges. MTM has resulted in cracks in the foundation of housing, caused dust, noise, and collapsed drinking water wells, and destroyed streams for fishing and swimming (Copeland, 2011). It has also led to the relocation of entire communities (Rosenberg, 2000).

Several environmental organizations have argued that allowing valley fills under CWA Section 404 is unlawful because the mining overburden pollutes and destroys waterways often exceeding the standard covered by the permit (Copeland, 2011). Mining industries argue that MTM is essential to facilitate surface coal extraction in Appalachia due to the poor stability of the soil surrounding coal deposits making it unfeasible to use underground mining techniques (Copeland, 2011).
Those opposed to MTM have taken legal action to challenge MTM waste disposals in valley fills. For instance, in 1998 a West Virginia citizen group sued the state and the Corps for “failure to prevent or enforce against environmental violations caused by mountaintop removal practices” (Copeland, 2011). The main claim under SMCRA involved the state’s failure to enforce the Office of Surface Mining Reclamation and Enforcement (OSM) buffer zone rule protecting intermittent and perennial streams from coal mining disturbances (Copeland, 2011). The lawsuit also claimed that the Corps had been issuing permits which allowed disposal of waste in U.S. waters under permits distinct from the CWA that did not meet the minimum criteria for adverse effects (Copeland, 2011). The completion of the PEIS helped settle some of the claims. Another ruling held that “disposal of mining spoil in valley streams violates federal and state mining rules and the CWA” (Copeland, 2011). Mining spoil was reclassified to “waste material” requiring Section 402 permits and raising the regulatory hurdles for disposing of mining waste (Copeland, 2011). Unfortunately, this ruling was appealed and overturned due to jurisdiction and state sovereignty issues (Copeland, 2011).

In 2005 the EPA, Corps and other federal agencies released the FPEIS and identified three alternatives for improving coordination of regulatory efforts to limit the negative impacts of mountaintop mining (Copeland, 2011). After receiving more than 70,000 public comments and considering the input of industry and environmental groups, the agencies responded that the alternatives were appropriate for a programmatic EIS and that they would provide increased environmental protection (Copeland, 2011). The final PEIS rule requires that surface coal mining activities be constructed to minimize the amount of spoil placed outside the mined-out area and creating the least amount of land disturbance (Copeland, 2011).
Both industry and environmental groups said that the final rule does little to change the existing practice of disposing mountaintop-mining spoil into valleys and streams. There continues to be legal strife between environmental groups, the mining industry, and government agencies. For instance, OSM stated “a key purpose of the rule was to conform the regulation to historic practice of federal and state authorities” while environmental groups said “the final rule would allow stream burial and water quality degradation to continue at current rates” (Copeland, 2011). Despite the ongoing legal cases, regulations regarding permit distribution have become stricter as illustrated by the EPA veto of the Spruce No. 1 mine permit. This EPA decision was the first post-permit 404(c) action, first 404(c) protecting headwater stream ecosystems, and first veto addressing surface coal mining. Thus, although there have been many controversies in the legal realm of MTM, the EPA is taking actions to address the adverse effects of this practice.

Currently, there is no legal framework for the protection of human health from mountaintop mining activities. It could be argued that the environmental regulations of MTM serve to protect some aspects of public health. However, developing public health specific regulations of MTM is imperative because adverse effects on the environment do not directly reflect human health impacts.

**Current Projects**

**EPA Cumulative Impacts Assessment**

The EPA is working with the CDC, ATSDR, and academic institutions to develop approaches for assessing potential human and community health impacts of MTM. They are also striving to create better prediction tools by establishing a framework that will facilitate decision-making under complex conditions, diverse societal values, and multiple regulatory situations.
The Cumulative Impact Assessment will focus on aquatic ecosystems, terrestrial ecosystems, EJ, and human health. The approach is “watershed-based” relying upon science, data, and professional judgment to provide a baseline evaluation of both conditions and stressors for future study comparison. Only the initial phase of the air component in this effort has been funded. No additional funding is available to increase understanding of epidemiological and drinking water related human health responses. The in-house resources at the EPA will be used in the time being to refine and update the information that is available for these components.

A Cumulative Impact analysis will provide stakeholder with the capability to use a variety of science-based data to make informed decisions. A multi-agency partnership will allow individuals to use the products of this work to address agency-specific resource concerns and projections. The EPA’s efforts are geared toward using a Cumulative Impact Assessment to facilitate more coordinated and environmentally sound federal policy and decision-making on surface coal mining in Appalachia.

**EPA Air Exposure Modeling Study**

The EPA’s air modeling study will be assessing the impact of various types of air pollution caused by MTM sites on exposed populations. The team is constructing an emissions inventory for each of the many sources related to the mining operation and for the haul truck traffic (emission rates with their associated temporal & special variability). They will characterize each of the sources as point, area, volume, open pit, or instantaneous release from blasting. Next they will execute the air quality modeling approach to estimate the air pollutant concentration fields that result from MTM operations. Finally, population and public health impacts at the local level impacts will be determine from: (1) the estimated concentration fields
(2) a characterization of the population in the vicinity of the mining operation and (3) the use of an appropriate exposure model.

**EPA Environmental Justice Initiatives**

Recently the EPA has made environmental justice a high priority and strives to ensure communities do not face disproportionate impacts from industry activities such as MTM. The Office of Enforcement Compliance and Environmental Justice (OECEJ) is spearheading current EPA EJ initiatives. Their efforts are aimed at disseminating information to community members to help them make educated decisions and provide informed feedback during required public meetings for new mining projects.

One of the ways the OECEJ is reaching out to MTM communities is through a Mountaintop Mining Action Plan, which evaluates citizen issues and concerns. The EPA has undertaken “listening sessions”, community site tours, and engaged in an on-going dialogue with citizens from Appalachia to better understand the issues and concerns associated with MTM activities. During these efforts, citizens have cited issues such as loss of cultural heritage because of losing family cemeteries buried by rubble or coal companies closing county access roads. There has also been concern for and claims of losing drinking water sources, reported mud slides and land disturbances. These people also report truck traffic, air quality concerns, fears of toxic contamination, and intimidation from the coal companies. The OECEJ uses these community interactions to build relationships with residents and create trust for future projects.

A structured analysis of community survey data by Matt Lee of the EPA OECEJ is currently underway to establish EJ components of specific counties in WV. Mr. Lee is analyzing the 2010 Census American Communities Survey. He's trying to identify data fields that would
help illuminate EJ status. The ACS is the first part of the 2010 census that's been released and it may or may not have useful data for Boone County WV.

**Academic Efforts**

A Duke University study by Dr. Marie Lynn Miranda will look at public health impacts of MTM activity levels related to drinking water with two different projects. First her team will be compiling data on private wells, water quality, and potentially affected water resources in order to tie contaminants from well water to mining sources. Some of the elements they will be measuring include Selenium, Arsenic, Mercury, Lead, and Manganese. They want to assess how much mining activity is going on, where it is occurring and the distance injection sites and impoundment ponds are from homes. The second project involves linking potentially affected water resources/environmental variables that derive from MTM activities with vital birth and death records from West Virginia.

**Interventions and Recommendations**

1. Increased collaborative efforts must be made by government agencies such as the EPA, ATSDR, CDC, nonprofits/foundations and community organizations, as well as academic institutions to connect environmental impacts with the health risks posed by MTM.
2. Future epidemiologic research should focus on obtaining individual level data on exposure, covariates, and specific diseases that were elevated in past MTM studies.
3. Health impact screening tools should be implemented to place a proposed mining operation in a category requiring detailed health impact evaluation and development of mitigation strategies. The implementation of these screening practices into current MTM regulations and their effectiveness will be assessed and evaluated.
4. State and local governments should provide access to clean water, trash removal for all communities to reduce garbage burning, waste treatment facilities to reduce disposal of sewage and waste in streams. This could be subsidized with tax revenue from mining.
5. Public transportation should be available for residents in rural areas of Appalachia so they are able to access medical care. This could be subsidized with tax revenues from mining.

6. All coal mining locations should have an in place agreement to mitigate fugitive dust via for communities on and immediately adjacent to active MTM sites. It is recommended that state DEQ conduct additional assessment efforts to further evaluate this exposure concern such as receptor specific and ambient motoring for both PM 2.5 and PM 10 exposure and consider other requirement as needed. Residents should be educated in personal health protective steps and provided with any necessary equipment/supplies to mitigate health risks from PM exposure.

7. Federal air pollution regulations for MTM must be established that protect the health of surrounding communities.

8. According to Executive Order 12898 agencies must ensure that public documents, notices, and hearings relating to human health or the environment are concise, understandable, and readily accessible to the public.

9. Federal agencies should collect, maintain, and analyze information assessing and comparing environmental and human health risks borne by populations identified by race, national origin, or income. They should use this information to determine whether their programs, policies, and activities have disproportionately high and adverse human health or environmental effects on minority populations and low-income populations.

10. Restore the landscape to its original state in order to rebuild the natural and cultural heritage of Appalachia. This may stimulate the tourism industry and decrease the region’s reliance on the coal mining industry. It will also improve the quality of life potentially removing psychosocial stress for residents of Appalachia.

**Conclusion**

The multifaceted controversial nature of mountaintop mining makes policy implementation and public health interventions challenging. There is insufficient scientific evidence regarding the human health impacts of MTM, a necessary element in the policy development process. Policies must be formulated based on the most up to date scientific research in order to withstand litigation. The environmental justice component of MTM has been confirmed based on Census data and through evaluation of communities in WV. However,
actions to ameliorate the environmental injustices that may impact MTM communities are not always taken by the corresponding federal agencies.

The MTM Action plan created by the OECEJ is one of the ways the EPA is addressing the adverse EJ effects experienced by the WV communities through education and information dissemination. Efforts should also be made to restore the natural and cultural heritage while improving the quality of life for MTM communities. Furthermore, there are several federal and academic efforts underway to evaluate the human health impacts of MTM, which will hopefully create a gateway to enact legislation and policy to ameliorate adverse impacts on communities of WV.

Based on the findings of the HIA, additional epidemiological studies of mountaintop mining exposures and health impacts are imperative to develop the most effective policies that will protect the public health. Specifically, air pollution and water contaminants from MTM and their subsequent health impacts must be thoroughly evaluated.

The results of this HIA will be shared with EPA stakeholders to aid in policy decisions regarding the impact of MTM on human health.
References


## Appendix A. Health Impacts of Heavy Metals

<table>
<thead>
<tr>
<th>Heavy Metal</th>
<th>Health effects if exposed through drinking water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Skin damage, chronic bronchitis, hypertension, peripheral vascular disease, increased risk of gastric, bladder, lung and skin cancer&lt;sup&gt;1,2&lt;/sup&gt;.</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Kidney damage, chronic renal failure, skeletal damage, carcinogen implicated in lung and kidney cancer&lt;sup&gt;2&lt;/sup&gt;.</td>
</tr>
<tr>
<td>Chromium</td>
<td>Carcinogenic by inhalation; by ingestion, implicated in gastrointestinal, central nervous system, skin cancers&lt;sup&gt;3&lt;/sup&gt;.</td>
</tr>
<tr>
<td>Copper</td>
<td>GI distress, liver or kidney damage in long-term&lt;sup&gt;4&lt;/sup&gt;.</td>
</tr>
<tr>
<td>Iron</td>
<td>Hemochromatosis</td>
</tr>
<tr>
<td>Manganese</td>
<td>Neurotoxin. Behavior change and bradykinesia. In children, behavior change and decreased ability to learn and remember&lt;sup&gt;6,7&lt;/sup&gt;.</td>
</tr>
<tr>
<td>Lead</td>
<td>In children, physical or mental developmental delay. In adults, kidney disease, high blood pressure&lt;sup&gt;5&lt;/sup&gt;.</td>
</tr>
</tbody>
</table>
Appendix B. Mining Footprint for Several West Virginia Counties
Appendix C. Population Density for Several West Virginia Counties

U.S. - 9.2 %
WV - 9.7%
### Appendix E. Risk Analysis Matrix

#### MT Mining Health Risk Matrix

<table>
<thead>
<tr>
<th>Activity</th>
<th>Stressors</th>
<th>Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blasting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM10</td>
<td>Lung Cancer</td>
<td></td>
</tr>
<tr>
<td>PM2.5</td>
<td>Cardiovascular Diseases</td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>Hearing Loss</td>
<td></td>
</tr>
<tr>
<td>Fumes</td>
<td>Included nitrogen dioxide, nitric oxide, CO, ammonia</td>
<td></td>
</tr>
<tr>
<td>Fugitive Dust</td>
<td>Included nitrogen dioxide, nitric oxide, CO, ammonia</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Stressors</th>
<th>Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>Skin Irritation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upper Respiratory Tract Problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GI Tract Problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cancers (liver, bladder, lung, kidney, skin)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anemia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kidney Damage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nervous System Problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Infertility</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Birth Defects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developmental Delays</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parkinson’s Disease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rash</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nausea</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cardiovascular Disease</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Stressors</th>
<th>Health Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shiny Injection</td>
<td>Methemoglobinemia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skin Irritation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lung Damage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anemia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eye Irritation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cardiovascular Diseases</td>
<td></td>
</tr>
</tbody>
</table>

Studies: Hendryx, O’Donnell, Horn. Lung cancer mortality is elevated in coal mining areas of Appalachia.

Hendryx, O'Donnell, Horn. Lung cancer mortality is elevated in coal mining areas of Appalachia.

Hendryx, Fedorko, Anestis, Rothermel. GIS based analysis.

Studies: Hendryx, O’Donnell, Horn. Lung cancer mortality is elevated in coal mining areas of Appalachia.

Studies: Hendryx, O’Donnell, Horn. Lung cancer mortality is elevated in coal mining areas of Appalachia.

Hendryx, Fedorko, Anestis, Rothermel. GIS based analysis.
Appendix F. Adult Current Asthma in West Virginia 2005-2009

Data Source: Behavioral Risk Factor Surveillance System.
Population: West Virginians age 18 and older.
Current Asthma – Responding “yes” to both “Have you ever been told by a doctor, nurse, or other health professional that you had asthma?” and “Do you still have asthma?”
Note: Multiple years of data and counties were combined for analysis. Individual county estimates are not available for all counties.
Appendix G. Pediatric Asthma Hospitalization Rates by County, West Virginia 2005-2009

Hospitalizations per 10,000 Population

- Southern Coalfield Region: 21.7 per 10,000
  (Mingo, McDowell, Monongalia, Raleigh, Summers, and Wyoming Counties)

- Eastern Panhandle Region: 8.8 per 10,000
  (Berkeley, Grant, Hampshire, Hardy, Jefferson, Monongalia, Morgan, and Pendleton Counties)

- Kanawha Valley Region: 10.5 per 10,000
  (Boone, Clay, Kanawha, and Putnam Counties)

- Northern Panhandle Region: 12.7 per 10,000
  (Brooke, Hancock, Marshall, Ohio, Wetzel, and Tyler Counties)

- Greenbrier Valley Region: 14.4 per 10,000
  (Braxton, Fayette, Greenbrier, Nicholas, Pocahontas, and Webster Counties)

- Western Region: 15.4 per 10,000
  (Doddridge, Gilmer, Harrison, Lewis, Marion, Meeker, Preston, Randolph, Taylor, Tucker, and Upshur Counties)

- Mid Ohio Valley Region: 10.5 per 10,000
  (Calhoun, Pleasure, Ritchie, Roane, Wirt, and Wood Counties)

WV = 17.0

Data Source: West Virginia Health Care Authority HICD9 Data; West Virginia Health Statistics Center
Appendix H. Cancer Incidence Rates in Boone County and West Virginia

![Chart showing 5-Year Average Age-Adjusted Incidence Rates](chart.png)

Appendix I. Cancer Incidence Rates of West Virginia Counties

<table>
<thead>
<tr>
<th>Site</th>
<th>Boone County</th>
<th>Kanawha County</th>
<th>Lincoln County</th>
<th>Logan County</th>
<th>Raleigh County</th>
<th>Wyoming County</th>
<th>West Virginia</th>
</tr>
</thead>
<tbody>
<tr>
<td>All sites</td>
<td>491.6</td>
<td>526.1</td>
<td>549.4</td>
<td>546.2</td>
<td>453.1</td>
<td>490.1</td>
<td>499.9</td>
</tr>
<tr>
<td>Brain &amp; Other Nervous Systems</td>
<td>9.4</td>
<td>7.9</td>
<td>2.7</td>
<td>10.5</td>
<td>7.1</td>
<td>6.8</td>
<td>7.6</td>
</tr>
<tr>
<td>Breast (Female Only)</td>
<td>93.0</td>
<td>121.6</td>
<td>95.2</td>
<td>106.3</td>
<td>94.4</td>
<td>104.0</td>
<td>112.8</td>
</tr>
<tr>
<td>Buccal Cavity &amp; Pharynx</td>
<td>11.4</td>
<td>12.3</td>
<td>21.1</td>
<td>17.5</td>
<td>10.3</td>
<td>5.7</td>
<td>11.5</td>
</tr>
<tr>
<td>Colon &amp; Rectum</td>
<td>55.7</td>
<td>52.1</td>
<td>60.6</td>
<td>62.0</td>
<td>57.6</td>
<td>56.8</td>
<td>55.1</td>
</tr>
<tr>
<td>Corpus-Uterus</td>
<td>29.3</td>
<td>26.9</td>
<td>34.8</td>
<td>36.6</td>
<td>33.2</td>
<td>24.8</td>
<td>29.0</td>
</tr>
<tr>
<td>Kidney &amp; Renal Pelvis</td>
<td>16.7</td>
<td>17.8</td>
<td>15.1</td>
<td>17.3</td>
<td>16.7</td>
<td>16.6</td>
<td>16.6</td>
</tr>
<tr>
<td>Larynx</td>
<td>11.2</td>
<td>4.9</td>
<td>9.5</td>
<td>11.6</td>
<td>5.1</td>
<td>6.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Leukemia</td>
<td>12.4</td>
<td>15.0</td>
<td>18.7</td>
<td>15.4</td>
<td>13.2</td>
<td>17.7</td>
<td>13.8</td>
</tr>
<tr>
<td>Liver &amp; Bile Duct</td>
<td>2.8</td>
<td>5.2</td>
<td>6.2</td>
<td>3.4</td>
<td>6.1</td>
<td>4.7</td>
<td>4.8</td>
</tr>
<tr>
<td>Lung &amp; Bronchus</td>
<td>132.8</td>
<td>94.7</td>
<td>134.5</td>
<td>125.3</td>
<td>77.5</td>
<td>108.3</td>
<td>91.4</td>
</tr>
<tr>
<td>Melanoma of the Skin</td>
<td>9.6</td>
<td>22.5</td>
<td>16.5</td>
<td>20.3</td>
<td>16.0</td>
<td>13.5</td>
<td>18.7</td>
</tr>
<tr>
<td>Non-Hodgkin’s Lymphoma</td>
<td>16.1</td>
<td>21.1</td>
<td>22.5</td>
<td>17.1</td>
<td>18.2</td>
<td>19.7</td>
<td>20.3</td>
</tr>
<tr>
<td>Pancreas</td>
<td>10.3</td>
<td>11.0</td>
<td>8.7</td>
<td>9.9</td>
<td>9.2</td>
<td>10.7</td>
<td>10.5</td>
</tr>
<tr>
<td>Prostate</td>
<td>98.5</td>
<td>154.5</td>
<td>128.9</td>
<td>129.1</td>
<td>117.5</td>
<td>124.7</td>
<td>141.1</td>
</tr>
<tr>
<td>Thyroid</td>
<td>9.7</td>
<td>12.9</td>
<td>7.7</td>
<td>13.5</td>
<td>10.6</td>
<td>9.1</td>
<td>10.8</td>
</tr>
<tr>
<td>Urinary Bladder</td>
<td>18.3</td>
<td>23.1</td>
<td>19.5</td>
<td>24.8</td>
<td>21.1</td>
<td>27.6</td>
<td>23.6</td>
</tr>
</tbody>
</table>

Highlighted cells based on numbers less than 16. Rates are unreliable and should be interpreted with caution.
Cancer data provided by the West Virginia Cancer Registry.
References for Appendix A


